REPORT

OF THE

FIFTY-NINTH MEETING

OF THE

BRITISH ASSOCIATION

FOR THE

ADVANCEMENT OF SCIENCE

HELD AT

NEWCASTLE-UPON-TYNE IN SEPTEMBER 1889.

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OBJECTS.

The Association contemplates no interference with the ground occupied by other institutions. Its objects are:—To give a stronger impulse and a more systematic direction to scientific inquiry,—to promote the intercourse of those who cultivate Science in different parts of the British Empire, with one another and with foreign philosophers,—to obtain a more general attention to the objects of Science, and a removal of any disadvantages of a public kind which impede its progress.

RULES.

Admission of Members and Associates.

All persons who have attended the first Meeting shall be entitled to become Members of the Association, upon subscribing an obligation to conform to its Rules.

The Fellows and Members of Chartered Literary and Philosophical Societies publishing Transactions, in the British Empire, shall be entitled, in like manner, to become Members of the Association.

The Officers and Members of the Councils, or Managing Committees, of Philosophical Institutions shall be entitled, in like manner, to become Members of the Association.

All Members of a Philosophical Institution recommended by its Council or Managing Committee shall be entitled, in like manner, to become Members of the Association.

Persons not belonging to such Institutions shall be elected by the General Committee or Council, to become Life Members of the Association, Annual Subscribers, or Associates for the year, subject to the approval of a General Meeting.

Compositions, Subscriptions, and Privileges.

Life Members shall pay, on admission, the sum of Ten Pounds. They shall receive *gratuitously* the Reports of the Association which may be published after the date of such payment. They are eligible to all the offices of the Association.

Annual Subscribers shall pay, on admission, the sum of Two Pounds, and in each following year the sum of One Pound. They shall receive

gratuitously the Reports of the Association for the year of their admission and for the years in which they continue to pay *without intermission* their Annual Subscription. By omitting to pay this subscription in any particular year, Members of this class (Annual Subscribers) *lose for that and all future years* the privilege of receiving the volumes of the Association *gratis:* but they may resume their Membership and other privileges at any subsequent Meeting of the Association, paying on each such occasion the sum of One Pound. They are eligible to all the Offices of the Association.

ASSOCIATES for the year shall pay on admission the sum of One Pound. They shall not receive *gratuitously* the Reports of the Association, nor be eligible to serve on Committees, or to hold any office.

The Association consists of the following classes:—

1. Life Members admitted from 1831 to 1845 inclusive, who have paid on admission Five Pounds as a composition.
2. Life Members who in 1846, or in subsequent years, have paid on admission Ten Pounds as a composition.
3. Annual Members admitted from 1831 to 1839 inclusive, subject to the payment of One Pound annually. [May resume their Membership after intermission of Annual Payment.]
4. Annual Members admitted in any year since 1839, subject to the payment of Two Pounds for the first year, and One Pound in each following year. [May resume their Membership after intermission of Annual Payment.]
5. Associates for the year, subject to the payment of One Pound.
6. Corresponding Members nominated by the Council.

And the Members and Associates will be entitled to receive the annual volume of Reports, *gratis*, or to *purchase* it at reduced (or Members') price, according to the following specification, viz.:—

1. *Gratis.*—Old Life Members who have paid Five Pounds as a composition for Annual Payments, and previous to 1845 a further sum of Two Pounds as a Book Subscription, or, since 1845, a further sum of Five Pounds.

   New Life Members who have paid Ten Pounds as a composition.

   Annual Members *who have not intermitted* their Annual Subscription.

2. *At reduced or Members' Price*, viz., two-thirds of the Publication Price. —Old Life Members who have paid Five Pounds as a composition for Annual Payments, but no further sum as a Book Subscription.

   Annual Members who have intermitted their Annual Subscription.

   Associates for the year. [Privilege confined to the volume for that year only.]

3. Members may purchase (for the purpose of completing their sets) any of the volumes of the Reports of the Association up to 1874, *of which more than* 15 *copies remain*, at 2*s.* 6*d.* per volume.[1]

Application to be made at the Office of the Association, 22 Albemarle Street, London, W.

Volumes not claimed within two years of the date of publication can only be issued by direction of the Council.

Subscriptions shall be received by the Treasurer or Secretaries.

[1] A few complete sets, 1831 to 1874, are on sale, at £10 the set.

Meetings.

The Association shall meet annually, for one week, or longer. The place of each Meeting shall be appointed by the General Committee two years in advance; and the arrangements for it shall be entrusted to the Officers of the Association.

General Committee.

The General Committee shall sit during the week of the Meeting, or longer, to transact the business of the Association. It shall consist of the following persons:—

Class A. Permanent Members.

1. Members of the Council, Presidents of the Association, and Presidents of Sections for the present and preceding years, with Authors of Reports in the Transactions of the Association.

2. Members who by the publication of Works or Papers have furthered the advancement of those subjects which are taken into consideration at the Sectional Meetings of the Association. *With a view of submitting new claims under this Rule to the decision of the Council, they must be sent to the Secretary at least one month before the Meeting of the Association. The decision of the Council on the claims of any Member of the Association to be placed on the list of the General Committee to be final.*

Class B. Temporary Members.[1]

1. Delegates nominated by the Corresponding Societies under the conditions hereinafter explained. *Claims under this Rule to be sent to the Secretary before the opening of the Meeting.*

2. Office-bearers for the time being, or delegates, altogether not exceeding three, from Scientific Institutions established in the place of Meeting. *Claims under this Rule to be approved by the Local Secretaries before the opening of the Meeting.*

3. Foreigners and other individuals whose assistance is desired, and who are specially nominated in writing, for the Meeting of the year, by the President and General Secretaries.

4. Vice-Presidents and Secretaries of Sections.

Organizing Sectional Committees.[2]

The Presidents, Vice-Presidents, and Secretaries of the several Sections are nominated by the Council, and have power to act until their names are submitted to the General Committee for election.

From the time of their nomination they constitute Organizing Committees for the purpose of obtaining information upon the Memoirs and Reports likely to be submitted to the Sections,[3] and of preparing Reports

[1] Revised by the General Committee, 1884.

[2] Passed by the General Committee, Edinburgh, 1871.

[3] *Notice to Contributors of Memoirs.*—Authors are reminded that, under an arrangement dating from 1871, the acceptance of Memoirs, and the days on which they are to be read, are now as far as possible determined by Organizing Committees for the several Sections *before the beginning of the Meeting.* It has therefore become necessary, in order to give an opportunity to the Committees of doing justice to the

thereon, and on the order in which it is desirable that they should be read, to be presented to the Committees of the Sections at their first meeting. The Sectional Presidents of former years are *ex officio* members of the Organizing Sectional Committees.[1]

An Organizing Committee may also hold such preliminary meetings as the President of the Committee thinks expedient, but shall, under any circumstances, meet on the first Wednesday of the Annual Meeting, at 11 A.M., to nominate the first members of the Sectional Committee, if they shall consider it expedient to do so, and to settle the terms of their report to the General Committee, after which their functions as an Organizing Committee shall cease.[2]

Constitution of the Sectional Committees.[3]

On the first day of the Annual Meeting, the President, Vice-Presidents, and Secretaries of each Section having been appointed by the General Committee, these Officers, and those previous Presidents and Vice-Presidents of the Section who may desire to attend, are to meet, at 2 P.M., in their Committee Rooms, and enlarge the Sectional Committees by selecting individuals from among the Members (not Associates) present at the Meeting whose assistance they may particularly desire. The Sectional Committees thus constituted shall have power to add to their number from day to day.

The List thus formed is to be entered daily in the Sectional Minute-Book, and a copy forwarded without delay to the Printer, who is charged with publishing the same before 8 A.M. on the next day in the Journal of the Sectional Proceedings.

Business of the Sectional Committees.

Committee Meetings are to be held on the Wednesday at 2 P.M., on the following Thursday, Friday, Saturday,[4] Monday, and Tuesday, from 10 to 11 A.M., punctually, for the objects stated in the Rules of the Association, and specified below.

The business is to be conducted in the following manner:—

1. The President shall call on the Secretary to read the minutes of the previous Meeting of the Committee.
2. No paper shall be read until it has been formally accepted by the

several Communications, that each author should prepare an Abstract of his Memoir of a length suitable for insertion in the published Transactions of the Association, and that he should send it, together with the original Memoir, by book-post, on or before........................., addressed thus—'General Secretaries, British Association, 22 Albemarle Street, London, W. For Section.........' If it should be inconvenient to the Author that his paper should be read on any particular days, he is requested to send information thereof to the Secretaries in a separate note. Authors who send in their MSS. three complete weeks before the Meeting, and whose papers are accepted, will be furnished, before the Meeting, with printed copies of their Reports and abstracts. No Report, Paper, or Abstract can be inserted in the Annual Volume unless it is handed either to the Recorder of the Section or to the Secretary, *before the conclusion of the Meeting.*

[1] Added by the General Committee, Sheffield, 1879.

[2] Revised by the General Committee, Swansea, 1880.

[3] Passed by the General Committee, Edinburgh, 1871.

[4] The meeting on Saturday was made optional by the General Committee at Southport, 1883.

Committee of the Section, and entered on the minutes accordingly.

3. Papers which have been reported on unfavourably by the Organizing Committees shall not be brought before the Sectional Committees.[1]

At the first meeting, one of the Secretaries will read the Minutes of last year's proceedings, as recorded in the Minute-Book, and the Synopsis of Recommendations adopted at the last Meeting of the Association and printed in the last volume of the Report. He will next proceed to read the Report of the Organizing Committee.[2] The list of Communications to be read on Thursday shall be then arranged, and the general distribution of business throughout the week shall be provisionally appointed. At the close of the Committee Meeting the Secretaries shall forward to the Printer a List of the Papers appointed to be read. The Printer is charged with publishing the same before 8 A.M. on Thursday in the Journal.

On the second day of the Annual Meeting, and the following days, the Secretaries are to correct, on a copy of the Journal, the list of papers which have been read on that day, to add to it a list of those appointed to be read on the next day, and to send this copy of the Journal as early in the day as possible to the Printer, who is charged with printing the same before 8 A.M. next morning in the Journal. It is necessary that one of the Secretaries of each Section (generally the Recorder) should call at the Printing Office and revise the proof each evening.

Minutes of the proceedings of every Committee are to be entered daily in the Minute-Book, which should be confirmed at the next meeting of the Committee.

Lists of the Reports and Memoirs read in the Sections are to be entered in the Minute-Book daily, which, with *all Memoirs and Copies or Abstracts of Memoirs furnished by Authors, are to be forwarded, at the close of the Sectional Meetings*, to the Secretary.

The Vice-Presidents and Secretaries of Sections become *ex officio* temporary Members of the General Committee (*vide* p. xxx), and will receive, on application to the Treasurer in the Reception Room, Tickets entitling them to attend its Meetings.

The Committees will take into consideration any suggestions which may be offered by their Members for the advancement of Science. They are specially requested to review the recommendations adopted at preceding Meetings, as published in the volumes of the Association, and the communications made to the Sections at this Meeting, for the purposes of selecting definite points of research to which individual or combined exertion may be usefully directed, and branches of knowledge on the state and progress of which Reports are wanted; to name individuals or Committees for the execution of such Reports or researches; and to state whether, and to what degree, these objects may be usefully advanced by the appropriation of the funds of the Association, by application to Government, Philosophical Institutions, or Local Authorities.

In case of appointment of Committees for special objects of Science, it is expedient that *all Members of the Committee should be named, and*

[1] These rules were adopted by the General Committee, Plymouth, 1877.

[2] This and the following sentence were added by the General Committee, Edinburgh, 1871.

one of them appointed to act as Chairman, who shall have notified personally or in writing his willingness to accept the office, the Chairman to have the responsibility of receiving and disbursing the grant (if any has been made) and securing the presentation of the Report in due time; and further, it is expedient that one of the members should be appointed to act as Secretary, for insuring attention to business.

That it is desirable that the number of Members appointed to serve on a Committee should be as small as is consistent with its efficient working.

That a tabular list of the Committees appointed on the recommendation of each Section should be sent each year to the Recorders of the several Sections, to enable them to fill in the statement whether the several Committees appointed on the recommendation of their respective Sections had presented their reports.

That on the proposal to recommend the appointment of a Committee for a special object of science having been adopted by the Sectional Committee, the number of Members of such Committee be then fixed, but that the Members to serve on such Committee be nominated and selected by the Sectional Committee at a subsequent meeting.[1]

Committees have power to add to their number persons whose assistance they may require.

The recommendations adopted by the Committees of Sections are to be registered in the Forms furnished to their Secretaries, and one Copy of each is to be forwarded, without delay, to the Secretary for presentation to the Committee of Recommendations. *Unless this be done, the Recommendations cannot receive the sanction of the Association.*

N.B.—Recommendations which may originate in any one of the Sections must *first be sanctioned by the Committee of that Section* before they can be referred to the Committee of Recommendations or confirmed by the General Committee.

The Committees of the Sections shall ascertain whether a Report has been made by every Committee appointed at the previous Meeting to whom a sum of money has been granted, and shall report to the Committee of Recommendations in every case where no such Report has been received.[2]

Notices regarding Grants of Money.

Committees and individuals, to whom grants of money have been entrusted by the Association for the prosecution of particular researches in science, are required to present to each following Meeting of the Association a Report of the progress which has been made; and the Chairman of a Committee to whom a money grant has been made must (previously to the next Meeting of the Association) forward to the General Secretaries or Treasurer a statement of the sums which have been expended, and the balance which remains disposable on each grant.

Grants of money sanctioned at any one Meeting of the Association expire *a week before* the opening of the ensuing Meeting; nor is the Treasurer authorized, after that date, to allow any claims on account of such grants, unless they be renewed in the original or a modified form by the General Committee.

No Committee shall raise money in the name or under the auspices

[1] Revised by the General Committee, Bath, 1888.
[2] Passed by the General Committee at Sheffield, 1879.

of the British Association without special permission from the General Committee to do so; and no money so raised shall be expended except in accordance with the rules of the Association.

In each Committee, the Chairman is the only person entitled to call on the Treasurer, Professor A. W. Williamson, 17 Buckingham Street, London, W.C., for such portion of the sums granted as may from time to time be required.

In grants of money to Committees, the Association does not contemplate the payment of personal expenses to the members.

In all cases where additional grants of money are made for the continuation of Researches at the cost of the Association, the sum named is deemed to include, as a part of the amount, whatever balance may remain unpaid on the former grant for the same object.

All Instruments, Papers, Drawings, and other property of the Association are to be deposited at the Office of the Association, 22 Albemarle Street, Piccadilly, London, W., when not employed in carrying on scientific inquiries for the Association.

Business of the Sections.

The Meeting Room of each Section is opened for conversation from 10 to 11 daily. *The Section Rooms and approaches thereto can be used for no notices, exhibitions, or other purposes than those of the Association.*

At 11 precisely the Chair will be taken,[1] and the reading of communications, in the order previously made public, commenced. At 3 P.M. the Sections will close.

Sections may, by the desire of the Committees, divide themselves into Departments, as often as the number and nature of the communications delivered in may render such divisions desirable.

A Report presented to the Association, and read to the Section which originally called for it, may be read in another Section, at the request of the Officers of that Section, with the consent of the Author.

Duties of the Doorkeepers.

1.—To remain constantly at the Doors of the Rooms to which they are appointed during the whole time for which they are engaged.

2.—To require of every person desirous of entering the Rooms the exhibition of a Member's, Associate's, or Lady's Ticket, or Reporter's Ticket, signed by the Treasurer, or a Special Ticket signed by the Secretary.

3.—Persons unprovided with any of these Tickets can only be admitted to any particular Room by order of the Secretary in that Room.

No person is exempt from these Rules, except those Officers of the Association whose names are printed in the programme, p. 1.

Duties of the Messengers.

To remain constantly at the Rooms to which they are appointed during the whole time for which they are engaged, except when employed on messages by one of the Officers directing these Rooms.

[1] The sectional meetings on Saturday and on Wednesday may begin at any time which may be fixed by the Committee, not earlier than 10 or later than 11. Passed by the General Committee at Bath, 1888.

Committee of Recommendations.

The General Committee shall appoint at each Meeting a Committee, which shall receive and consider the Recommendations of the Sectional Committees, and report to the General Committee the measures which they would advise to be adopted for the advancement of Science.

All Recommendations of Grants of Money, Requests for Special Researches, and Reports on Scientific Subjects shall be submitted to the Committee of Recommendations, and not taken into consideration by the General Committee unless previously recommended by the Committee of Recommendations.

Corresponding Societies.[1]

(1.) Any Society is eligible to be placed on the List of Corresponding Societies of the Association which undertakes local scientific investigations, and publishes notices of the results.

(2.) Application may be made by any Society to be placed on the List of Corresponding Societies. Applications must be addressed to the Secretary on or before the 1st of June preceding the Annual Meeting at which it is intended they should be considered, and must be accompanied by specimens of the publications of the results of the local scientific investigations recently undertaken by the Society.

(3.) A Corresponding Societies Committee shall be annually nominated by the Council and appointed by the General Committee for the purpose of considering these applications, as well as for that of keeping themselves generally informed of the annual work of the Corresponding Societies, and of superintending the preparation of a list of the papers published by them. This Committee shall make an annual report to the General Committee, and shall suggest such additions or changes in the List of Corresponding Societies as they may think desirable.

(4.) Every Corresponding Society shall return each year, on or before the 1st of June, to the Secretary of the Association, a schedule, properly filled up, which will be issued by the Secretary of the Association, and which will contain a request for such particulars with regard to the Society as may be required for the information of the Corresponding Societies Committee.

(5.) There shall be inserted in the Annual Report of the Association a list, in an abbreviated form, of the papers published by the Corresponding Societies during the past twelve months which contain the results of the local scientific work conducted by them; those papers only being included which refer to subjects coming under the cognisance of one or other of the various Sections of the Association.

(6.) A Corresponding Society shall have the right to nominate any one of its members, who is also a Member of the Association, as its delegate to the Annual Meeting of the Association, who shall be for the time a Member of the General Committee.

Conference of Delegates of Corresponding Societies.

(7.) The Conference of Delegates of Corresponding Societies is empowered to send recommendations to the Committee of Recommendations for their consideration, and for report to the General Committee.

[1] Passed by the General Committee, 1884.

(8.) The Delegates of the various Corresponding Societies shall constitute a Conference, of which the Chairman, Vice-Chairmen, and Secretaries shall be annually nominated by the Council, and appointed by the General Committee, and of which the members of the Corresponding Societies Committee shall be *ex officio* members.

(9.) The Conference of Delegates shall be summoned by the Secretaries to hold one or more meetings during each Annual Meeting of the Association, and shall be empowered to invite any Member or Associate to take part in the meetings.

(10.) The Secretaries of each Section shall be instructed to transmit to the Secretaries of the Conference of Delegates copies of any recommendations forwarded by the Presidents of Sections to the Committee of Recommendations bearing upon matters in which the co-operation of Corresponding Societies is desired; and the Secretaries of the Conference of Delegates shall invite the authors of these recommendations to attend the meetings of the Conference and give verbal explanations of their objects and of the precise way in which they would desire to have them carried into effect.

(11.) It will be the duty of the Delegates to make themselves familiar with the purport of the several recommendations brought before the Conference, in order that they and others who take part in the meetings may be able to bring those recommendations clearly and favourably before their respective Societies. The Conference may also discuss propositions bearing on the promotion of more systematic observation and plans of operation, and of greater uniformity in the mode of publishing results.

Local Committees.

Local Committees shall be formed by the Officers of the Association to assist in making arrangements for the Meetings.

Local Committees shall have the power of adding to their numbers those Members of the Association whose assistance they may desire.

Officers.

A President, two or more Vice-Presidents, one or more Secretaries, and a Treasurer shall be annually appointed by the General Committee.

Council.

In the intervals of the Meetings, the affairs of the Association shall be managed by a Council appointed by the General Committee. The Council may also assemble for the despatch of business during the week of the Meeting.

(1) The Council shall consist of[1]

1. The Trustees.
2. The past Presidents.
3. The President and Vice-Presidents for the time being.
4. The President and Vice-Presidents elect.
5. The past and present General Treasurers, General and Assistant General Secretaries.

[1] Passed by the General Committee, Belfast, 1874.

6. The Local Treasurer and Secretaries for the ensuing Meeting.
7. Ordinary Members.

(2) The Ordinary Members shall be elected annually from the General Committee.
(3) There shall be not more than twenty-five Ordinary Members, of whom not more than twenty shall have served on the Council, as Ordinary Members, in the previous year.
(4) In order to carry out the foregoing rule, the following Ordinary Members of the outgoing Council shall at each annual election be ineligible for nomination:—1st, those who have served on the Council for the greatest number of consecutive years; and, 2nd, those who, being resident in or near London, have attended the fewest number of Meetings during the year —observing (as nearly as possible) the proportion of three by seniority to two by least attendance.
(5) The Council shall submit to the General Committee in their Annual Report the names of the Members of General Committee whom they recommend for election as Members of Council.
(6) The Election shall take place at the same time as that of the Officers of the Association.

Papers and Communications.

The Author of any paper or communication shall be at liberty to reserve his right of property therein.

Accounts.

The Accounts of the Association shall be audited annually, by Auditors appointed by the General Committee.

Table showing the Places and Times of Meeting of the British Association, with Presidents, Vice-Presidents, and Local Secretaries, from its Commencement.

PRESIDENTS.	VICE-PRESIDENTS.	LOCAL SECRETARIES.
The EARL FITZWILLIAM, D.C.L., F.R.S., F.G.S., &c. YORK, September 27, 1831.	Rev. W. Vernon Harcourt, M.A., F.R.S., F.G.S.	William Gray, jun., Esq., F.G.S. Professor Phillips, M.A., F.R.S., F.G.S.
The REV. W. BUCKLAND, D.D., F.R.S., F.G.S., &c. OXFORD, June 19, 1832.	Sir David Brewster, F.R.S. L. & E., &c. Rev. W. Whewell, F.R.S., Pres. Geol. Soc.	Professor Daubeny, M.D., F.R.S., &c. Rev. Professor Powell, M.A., F.R.S., &c.
The REV. ADAM SEDGWICK, M.A., V.P.R.S., V.P.G.S. CAMBRIDGE, June 25, 1833.	G. B. Airy, Esq., F.R.S., Astronomer Royal, &c. John Dalton, Esq., D.C.L., F.R.S.	Rev. Professor Henslow, M.A., F.L.S., F.G.S. Rev. W. Whewell, F.R.S.
SIR T. MACDOUGALL BRISBANE, K.C.B., D.C.L., F.R.S. L. & E. EDINBURGH, September 8, 1834.	Sir David Brewster, F.R.S., &c. Rev. T. R. Robinson, D.D.	Professor Forbes, F.R.S. L. & E., &c. Sir John Robinson, Sec. R.S.E.
The REV. PROVOST LLOYD, LL.D. DUBLIN, August 10, 1835.	Viscount Oxmantown, F.R.S., F.R.A.S. Rev. W. Whewell, F.R.S., &c.	Sir W. R. Hamilton, Astron. Royal of Ireland, &c. Rev. Professor Lloyd, F.R.S.
The MARQUIS OF LANSDOWNE, D.C.L., F.R.S., BRISTOL, August 22, 1836.	The Marquis of Northampton, F.R.S. Rev. W. D. Conybeare, F.R.S., F.G.S. J. C. Prichard, Esq., M.D., F.R.S.	Professor Daubeny, M.D., F.R.S., &c. V. F. Hovenden, Esq.
The EARL OF BURLINGTON, F.R.S., F.G.S., Chancellor of the University of London LIVERPOOL, September 11, 1837.	The Bishop of Norwich, P.L.S., F.G.S. John Dalton, Esq., D.C.L., F.R.S. Sir Philip de Grey Egerton, Bart., F.R.S., F.G.S. Rev. W. Whewell, F.R.S.	Professor Traill, M.D. Wm. Wallace Currie, Esq. Joseph N. Walker, Esq., Pres. Royal Institution, Liverpool.
The DUKE OF NORTHUMBERLAND, F.R.S., F.G.S., &c. NEWCASTLE-ON-TYNE, August 20, 1838.	The Bishop of Durham, F.R.S., F.S.A. The Rev. W. Vernon Harcourt, F.R.S., &c. Prideaux John Selby, Esq., F.R.S.E.	John Adamson, Esq., F.L.S., &c. Wm. Hutton, Esq., F.G.S. Professor Johnston, M.A., F.R.S.
The REV. W. VERNON HARCOURT, M.A., F.R.S., &c. BIRMINGHAM, August 26, 1839.	The Marquis of Northampton. The Earl of Dartmouth The Rev. T. R. Robinson, D.D. John Corrie, Esq., F.R.S. The Very Rev. Principal Macfarlane	George Barker, Esq., F.R.S. Peyton Blakiston, Esq., M.D. Joseph Hodgson, Esq., F.R.S. Follett Osler, Esq.
The MARQUIS OF BREADALBANE, F.R.S. GLASGOW, September 17, 1840.	Major-General Lord Greenock, F.R.S.E. Sir David Brewster, F.R.S. Sir T. M. Brisbane, Bart., F.R.S. The Earl of Mount-Edgcumbe	Andrew Liddell, Esq. Rev. J. P. Nicol, LL.D. John Strang, Esq.
The REV. PROFESSOR WHEWELL, F.R.S., &c. PLYMOUTH, July 29, 1841.	The Earl of Morley. Lord Eliot, M.P. Sir C. Lemon, Bart. Sir T. D. Acland, Bart.	W. Snow Harris, Esq., F.R.S. Col. Hamilton Smith, F.L.S. Robert Were Fox, Esq. Richard Taylor, jun., Esq
The LORD FRANCIS EGERTON, F.G.S. MANCHESTER, June 23, 1842.	John Dalton, Esq., D.C.L., F.R.S. Hon. and Rev. W. Herbert, F.L.S., &c. Rev. A. Sedgwick, M.A., F.R.S. W. C. Henry, Esq., M.D., F.R.S. Sir Benjamin Heywood, Bart	Peter Clare, Esq., F.R.A.S. W. Fleming, Esq., M.D. James Heywood, Esq., F.R.S.
The EARL OF ROSSE, F.R.S. CORK, August 17, 1843.	The Earl of Listowel. Viscount Adare Sir W. R. Hamilton, Pres. R.I.A. Rev. T. R. Robinson, D.D.	Professor John Stevelly, M.A. Rev. Jos. Carson, F.T.C. Dublin. William Keleher, Esq. Wm. Clear, Esq.
The REV. G. PEACOCK, D.D. (Dean of Ely), F.R.S. YORK, September 26, 1844.	Earl Fitzwilliam, F.R.S. Viscount Morpeth, F.G.S. The Hon. John Stuart Wortley, M.P. Sir David Brewster, K.H., F.R.S. Michael Faraday, Esq., D.C.L., F.R.S. Rev. W. V. Harcourt, F.R.S.	William Hatfeild, Esq., F.G.S. Thomas Meynell, Esq., F.L.S. Rev. W. Scoresby, LL.D., F.R.S. William West, Esq.
SIR JOHN F. W. HERSCHEL, Bart., F.R.S., &c. CAMBRIDGE, June 19, 1845.	The Earl of Hardwicke. The Bishop of Norwich Rev. J. Graham, D.D. Rev. G. Ainslie, D.D. G. B. Airy, Esq., M.A., D.C.L., F.R.S.	William Hopkins, Esq., M.A., F.R.S. Professor Ansted, M.A., F.R.S.

SIR RODERICK IMPEY MURCHISON, G.C.St.S., F.R.S. SOUTHAMPTON, September 10, 1846.	The Marquis of Winchester. The Earl of Yarborough, D.C.L. Lord Ashburton, D.C.L. Viscount Palmerston, M.P. Right Hon. Charles Shaw Lefevre, M.P. Sir George T. Staunton, Bart., M.P., D.C.L., F.R.S. The Lord Bishop of Oxford, F.R.S. Professor Owen, M.D., F.R.S. The Rev. Professor Powell, F.R.S.	Henry Clark, Esq., M.D. T. H. C. Moody, Esq.
SIR ROBERT HARRY INGLIS, Bart., D.C.L., F.R.S., M.P. for the University of Oxford OXFORD, June 23, 1847.	The Earl of Rosse, F.R.S. The Lord Bishop of Oxford, F.R.S. The Vice-Chancellor of the University Thomas G. Bucknall Estcourt, Esq., D.C.L., M.P. for the University of Oxford. The Very Rev. the Dean of Westminster, D.D., F.R.S. Professor Daubeny, M.D., F.R.S. The Rev. Prof. Powell, M.A., F.R.S.	Rev. Robert Walker, M.A., F.R.S. H. Wentworth Acland, Esq., B.M.
The MARQUIS OF NORTHAMPTON, President of the Royal Society, &c. SWANSEA, August 9, 1848.	The Marquis of Bute, K.T. Viscount Adare, F.R.S. Sir H. T. De la Beche, F.R.S., Pres. G.S. The Very Rev. the Dean of Llandaff, F.R.S. Lewis W. Dillwyn, Esq., F.R.S. W. R. Grove, Esq., F.R.S. J. H. Vivian, Esq., M.P., F.R.S. The Lord Bishop of St. David's	Matthew Moggridge, Esq. D. Nicol, Esq., M.D.
The REV. T. R. ROBINSON, D.D., M.R.I.A., F.R.A.S. BIRMINGHAM, September 12, 1849.	The Earl of Harrowby. The Lord Wrottesley, F.R.S. The Right Hon. Sir Robert Peel, Bart., M.P., D.C.L., F.R.S. Charles Darwin, Esq., M.A., F.R.S., Sec. G.S. Professor Faraday, D.C.L., F.R.S. Sir David Brewster, K.H., LL.D., F.R.S. Rev. Prof. Willis, M.A., F.R.S.	Captain Tindal, R.N. William Wills, Esq. Bell Fletcher, Esq., M.D. James Chance, Esq.
SIR DAVID BREWSTER, K.H., LL.D., F.R.S. L. & E., Principal of the United College of St. Salvator and St. Leonard, St. Andrews EDINBURGH, July 21, 1850.	The Right Hon. the Lord Provost of Edinburgh The Earl of Cathcart, K.C.B., F.R.S.E. The Earl of Rosebery, K.T., D.C.L., F.R.S. The Right Hon. David Boyle (Lord Justice-General), F.R.S.E. General Sir Thomas M. Brisbane, Bart., D.C.L., F.R.S., Pres. R.S.E. The Very Rev. John Lee, D.D., V.P.R.S.E., Principal of the University of Edinburgh. Professor W. P. Alison, M.D., V.P.R.S.E. Professor J. D. Forbes, F.R.S., Sec. R.S.E.	Rev. Professor Kelland, M.A., F.R.S. L. & E. Professor Balfour, M.D., F.R.S.E., F.L.S. James Tod, Esq., F.R.S.E.
GEORGE BIDDELL AIRY, Esq., D.C.L., F.R.S., Astronomer Royal IPSWICH, July 2, 1851.	The Lord Rendlesham, M.P. The Lord Bishop of Norwich Rev. Professor Sedgwick, M.A., F.R.S. Rev. Professor Henslow, M.A., F.L.S. Sir John P. Boileau, Bart., F.R.S. Sir William F. F. Middleton, Bart. J. C. Cobbold, Esq., M.P. T. B. Western, Esq.	Charles May, Esq., F.R.A.S. Dillwyn Sims, Esq. George Arthur Biddell, Esq. George Ransome, Esq., F.L.S.
COLONEL EDWARD SABINE, Royal Artillery, Treas. & V.P. of the Royal Society BELFAST, September 1, 1852.	The Earl of Enniskillen, D.C.L., F.R.S. The Earl of Rosse, Pres. R.S., M.R.I.A. Sir Henry T. De la Beche, F.R.S. Rev. Edward Hincks, D.D., M.R.I.A. Rev. P. S. Henry, D.D., Pres. Queen's College, Belfast Rev. T. R. Robinson, D.D., Pres. R.I.A., F.R.A.S. Professor G. G. Stokes, F.R.S. Professor Stevelly, LL.D.	W. J. C. Allen, Esq. William M'Gee, Esq., M.D. Professor W. P. Wilson.
WILLIAM HOPKINS, Esq., M.A., V.P.R.S., F.G.S., Pres. Camb. Phil. Society HULL, September 7, 1853.	The Earl of Carlisle, F.R.S. Lord Londesborough, F.R.S. Professor Faraday, D.C.L., F.R.S. Rev. Prof. Sedgwick, M.A., F.R.S. Charles Frost, Esq., F.S.A., Pres. of the Hull Lit. and Phil. Society William Spence, Esq., F.R.S. Lieut.-Col. Sykes, F.R.S. Professor Wheatstone, F.R.S.	Henry Cooper, Esq., M.D., V.P. Hull Lit. & Phil. Society. Bethel Jacobs, Esq., Pres. Hull Mechanics' Inst.

PRESIDENTS.	VICE-PRESIDENTS.	LOCAL SECRETARIES.
The EARL OF HARROWBY, F.R.S. LIVERPOOL, September 20, 1854.	The Lord Wrottesley, M.A., F.R.S., F.R.A.S. Sir Philip de Malpas Grey Egerton, Bart., M.P., F.R.S., F.G.S. Professor Owen, M.D., LL.D., F.R.S., F.L.S., F.G.S. Rev. Professor Whewell, D.D., F.R.S., Hon. M.R.I.A., F.G.S., Master of Trinity College, Cambridge William Lassell, Esq., F.R.S. L. & E., F.R.A.S. Joseph Brooks Yates, Esq., F.S.A., F.R.G.S	Joseph Dickinson, Esq., M.D., F.R.S. Thomas Inman, Esq., M.D.
The DUKE OF ARGYLL, F.R.S., F.G.S. GLASGOW, September 12, 1855.	The Very Rev. Principal Macfarlane, D.D. Sir William Jardine, Bart., F.R.S.E. Sir Charles Lyell, M.A., LL.D., F.R.S. James Smith, Esq., F.R.S. L. & E. Walter Crum, Esq., F.R.S. Thomas Graham, Esq., M.A., F.R.S., Master of the Royal Mint Professor William Thomson, M.A., F.R.S.	John Strang, Esq., LL.D. Professor Thomas Anderson, M.D. William Gourlie, Esq.
CHARLES G. B. DAUBENY, Esq., M.D., LL.D., F.R.S., Professor of Botany in the University of Oxford CHELTENHAM, August 6, 1856.	The Earl of Ducie, F.R.S., F.G.S. The Lord Bishop of Gloucester and Bristol Sir Roderick I. Murchison, G.C.St.S., D.C.L., F.R.S. Thomas Barwick Lloyd Baker, Esq. The Rev. Francis Close, M.A.	Capt. Robinson, R.A. Richard Beamish, Esq., F.R.S. John West Hugell, Esq.
The REV. HUMPHREY LLOYD, D.D., D.C.L., F.R.S. L. & E., V.P.R.I.A. DUBLIN, August 26, 1857.	The Right Hon. the Lord Mayor of Dublin The Provost of Trinity College, Dublin The Marquis of Kildare. Lord Talbot de Malahide The Lord Chancellor of Ireland The Lord Chief Baron, Dublin Sir William R. Hamilton, LL.D., F.R.A.S., Astronomer Royal of Ireland Lieut.-Colonel Larcom, R.E., LL.D., F.R.S. Richard Griffith, Esq., LL.D., M.R.I.A., F.R.S.E., F.G.S.	Lundy E. Foote, Esq. Rev. Professor Jellett, F.T.C.D. W. Neilson Hancock, Esq., LL.D.
RICHARD OWEN, Esq., M.D., D.C.L., V.P.R.S., F.L.S., F.G.S., Superintendent of the Natural History Departments of the British Museum. LEEDS, September 22, 1858.	The Lord Monteagle, F.R.S. The Lord Viscount Goderich, M.P., F.R.G.S. The Right Hon. M. T. Baines, M.A., M.P. Sir Philip de Malpas Grey Egerton, Bart., M.P., F.R.S., F.G.S. The Rev. W. Whewell, D.D., F.R.S., Hon. M.R.I.A., F.G.S., F.R.A.S., Master of Trinity College, Cambridge James Garth Marshall, Esq., M.A., F.G.S. R. Monckton Milnes, Esq., D.C.L., M.P., F.R.G.S.	Rev. Thomas Hincks, B.A. W. Sykes Ward, Esq., F.C.S. Thomas Wilson, Esq., M.A.
HIS ROYAL HIGHNESS THE PRINCE CONSORT ABERDEEN, September 14, 1859.	The Duke of Richmond, K.G., F.R.S. The Earl of Aberdeen, LL.D., K.G., K.T., F.R.S. The Lord Provost of the City of Aberdeen Sir John F. W. Herschel, Bart., M.A., D.C.L., F.R.S. Sir David Brewster, K.H., D.C.L., F.R.S. Sir Roderick I. Murchison, G.C.St.S., D.C.L., F.R.S. The Rev. W. V. Harcourt, M.A., F.R.S. The Rev. T. R. Robinson, D.D., F.R.S. A. Thomson, Esq., LL.D., F.R.S., Convener of the County of Aberdeen	Professor J. Nicol, F.R.S.E., F.G.S. Professor Fuller, M.A. John F. White, Esq.
The LORD WROTTESLEY, M.A., V.P.R.S., F.R.A.S. OXFORD, June 27, 1860.	The Earl of Derby, K.G., P.C., D.C.L., Chancellor of the Univ. of Oxford The Rev. F. Jeune, D.C.L., Vice-Chancellor of the University of Oxford The Duke of Marlborough, D.C.L., F.G.S., Lord Lieutenant of Oxfordshire The Earl of Rosse, K.P., M.A., F.R.S., F.R.A.S. The Lord Bishop of Oxford, D.D., F.R.S. The Very Rev. H. G. Liddell, D.D., Dean of Christ Church, Oxford Professor Daubeny, M.D., LL.D., F.R.S., F.L.S., F.G.S. [illegible] Professor Donkin, M.A., F.R.S., F.R.A.S.	George Rolleston, Esq., M.D., F.L.S. H. J. S. Smith, Esq., M.A., F.C.S. George Griffith, Esq., M.A., F.C.S.

WILLIAM FAIRBAIRN, Esq., LL.D., C.E., F.R.S. MANCHESTER, September 4, 1861.	The Earl of Ellesmere, F.R.G.S. The Lord Stanley, M.P., D.C.L., F.R.G.S. The Lord Bishop of Manchester, D.D., F.R.S., F.G.S. Sir Philip de Malpas Grey Egerton, Bart., M.P., F.R.S., F.G.S. Sir Benjamin Heywood, Bart., F.R.S. Thomas Bazley, Esq., M.P. James Aspinall Turner, Esq., M.P. James Prescott Joule, Esq., LL.D., F.R.S., Pres. Lit. & Phil. Soc. Manchester Professor E. Hodgkinson, F.R.S., M.R.I.A., M.Inst.C.E. Joseph Whitworth, Esq., F.R.S., M.Inst.C E.	R. D. Darbishire, Esq., B.A., F.G.S. Alfred Neild, Esq. Arthur Ransome, Esq., M.A. Professor H. E. Roscoe, B.A.
The REV. R. WILLIS, M.A., F.R.S., Jacksonian Professor of Natural and Experimental Philosophy in the University of Cambridge CAMBRIDGE, October 1, 1862.	The Rev. the Vice-Chancellor of the University of Cambridge The Very Rev. Harvey Goodwin, D.D., Dean of Ely The Rev. W. Whewell, D.D., F.R.S., Master of Trinity College, Cambridge The Rev. Professor Sedgwick, M.A., D.C.L., F.R.S. The Rev. J. Challis, M.A., F.R.S. G. B. Airy, Esq., M.A., D.C.L., F.R.S., Astronomer Royal Professor G. G. Stokes, M.A., D.C.L., Sec. R.S. Professor J. C. Adams, M.A., D.C.L., F.R.S., Pres. C.P.S.	Professor C. C. Babington, M.A., F.R.S., F.L.S. Professor G. D. Liveing, M.A. The Rev. N. M. Ferrers, M.A.
SIR W. ARMSTRONG, C.B., LL.D., F.R.S. NEWCASTLE-ON-TYNE, August 26, 1863.	Sir Walter C. Trevelyan, Bart., M.A. Sir Charles Lyell, LL.D., D.C.L., F.R.S., F.G.S. Hugh Taylor, Esq., Chairman of the Coal Trade Isaac Lowthian Bell, Esq., Mayor of Newcastle Nicholas Wood, Esq., President of the Northern Institute of Mining Engineers Rev. Temple Chevallier, B.D., F.R.A.S. William Fairbairn, Esq., LL.D., F.R.S.	A. Noble, Esq. Augustus H. Hunt, Esq. R. C. Clapham, Esq.
SIR CHARLES LYELL, Bart., M.A., D.C.L., F.R.S. BATH, September 14, 1864.	The Right Hon. the Earl of Cork and Orrery, Lord-Lieutenant of Somersetshire The Most Noble the Marquis of Bath The Right Hon. Earl Nelson The Right Hon. Lord Portman The Very Rev. the Dean of Hereford The Venerable the Archdeacon of Bath W. Tite, Esq., M.P., F.R.S., F.G.S., F.S.A. A. E. Way, Esq., M.P. Francis H. Dickinson, Esq. W. Sanders, Esq., F.R.S., F.G.S.	C. Moore, Esq., F.G.S. C. E. Davis, Esq. The Rev. H. H. Winwood, M.A.
JOHN PHILLIPS, Esq., M.A., LL.D., F.R.S., F.G.S., Professor of Geology in the University of Oxford BIRMINGHAM, September 6, 1865.	The Right Hon. the Earl of Lichfield, Lord-Lieutenant of Staffordshire The Right Hon. the Earl of Dudley The Right Hon. Lord Leigh, Lord-Lieutenant of Warwickshire The Right Hon. Lord Lyttelton, Lord-Lieutenant of Worcestershire The Right Hon. Lord Wrottesley, M.A., D.C.L., F.R.S., F.R.A.S. The Right Rev. the Lord Bishop of Worcester The Right Hon. C. B. Adderley, M.P. William Scholefield, Esq., M.P. F. Osler, Esq., F.R.S. J. T. Chance, Esq. The Rev. Charles Evans, M.A.	William Mathews, jun., Esq., M.A., F.G.S. John Henry Chamberlain, Esq. The Rev. G. D. Boyle, M.A.

PRESIDENTS.	VICE-PRESIDENTS.	LOCAL SECRETARIES.
WILLIAM R. GROVE, Esq., Q.C., M.A., F.R.S. NOTTINGHAM, August 22, 1866.	His Grace the Duke of Devonshire, Lord-Lieutenant of Derbyshire His Grace the Duke of Rutland, Lord-Lieutenant of Leicestershire The Right Hon. Lord Belper, Lord-Lieutenant of Nottinghamshire The Right Hon. J. E. Denison, M.P. J. C. Webb, Esq., High-Sheriff of Nottinghamshire Thomas Graham, Esq., F.R.S., Master of the Mint Joseph Hooker, Esq., M.D., F.R.S., F.L.S. John Russell Hind, Esq., F.R.S., F.R.A.S. T. Close, Esq.	Dr. Robertson. Edward J. Lowe, Esq., F.R.A.S., F.L.S. The Rev. J. F. M'Callan, M.A.
HIS GRACE THE DUKE OF BUCCLEUCH, K.G., D.C.L., F.R.S. DUNDEE, September 4, 1867.	The Right Hon. the Earl of Airlie, K.T. The Right Hon. the Lord Kinnaird, K.T. Sir John Ogilvy, Bart., M.P. Sir Roderick I. Murchison, Bart., K.C.B., LL.D., F.R.S., F.G.S., &c. Sir David Baxter, Bart. Sir David Brewster, D.C.L., F.R.S., Principal of the University of Edinburgh James D. Forbes, Esq., LL.D., F.R.S., Principal of the United College of St. Salvator and St. Leonard, University of St. Andrews	J. Henderson, jun., Esq. John Austin Lake Gloag, Esq. Patrick Anderson, Esq.
JOSEPH DALTON HOOKER, Esq., M.D., D.C.L., F.R.S., F.L.S. NORWICH, August 19, 1868.	The Right Hon. the Earl of Leicester, Lord-Lieutenant of Norfolk Sir John Peter Boileau, Bart., F.R.S. The Rev. Adam Sedgwick, M.A., LL.D., F.R.S., F.G.S., &c., Woodwardian Professor of Geology in the University of Cambridge Sir John Lubbock, Bart., F.R.S., F.L.S., F.G.S. John Couch Adams, Esq., M.A., D.C.L., F.R.S., F.R.A.S., Lowndean Professor of Astronomy and Geometry in the University of Cambridge Thomas Brightwell, Esq.	Dr. Donald Dalrymple. Rev. Joseph Crompton, M.A. Rev. Canon Hinds Howell.
PROFESSOR GEORGE G. STOKES, D.C.L., F.R.S. EXETER, August 18, 1869.	The Right Hon. the Earl of Devon The Right Hon. Sir Stafford H. Northcote, Bart., C.B., M.P., &c. Sir John Bowring, LL.D., F.R.S. William B. Carpenter, Esq., M.D., F.R.S., F.L.S. Robert Were Fox, Esq., F.R.S. W. H. Fox Talbot, Esq., M.A., LL.D., F.R.S., F.L.S.	Henry S. Ellis, Esq., F.R.A.S. John C. Bowring, Esq. The Rev. R. Kirwan.
PROFESSOR T. H. HUXLEY, LL.D., F.R.S. F.G.S. LIVERPOOL, September 14, 1870.	The Right Hon. the Earl of Derby, LL.D., F.R.S. Sir Philip de Malpas Grey Egerton, Bart., M.P. The Right Hon. W. E. Gladstone, D.C.L., M.P. S. R. Graves, Esq., M.P. Sir Joseph Whitworth, Bart., LL.D., D.C.L., F.R.S. James P. Joule, Esq., LL.D., D.C.L., F.R.S. Joseph Mayer, Esq., F.S.A., F.R.G.S.	Rev. W. Banister. Reginald Harrison, Esq. Rev. Henry H. Higgins, M.A. Rev. Dr. A. Hume, F.S.A.
PROFESSOR SIR WILLIAM THOMSON, M.A., LL.D., F.R.S. L. & E. EDINBURGH, August 2, 1871.	His Grace the Duke of Buccleuch, K.G., D.C.L., F.R.S. The Right Hon. the Lord Provost of Edinburgh The Right Hon. John Inglis, LL.D., Lord Justice-General of Scotland Sir Alexander Grant, Bart., M.A., Principal of the University of Edinburgh Sir Roderick I. Murchison, Bart., K.C.B., G.C.St.S., D.C.L., F.R.S. Sir Charles Lyell, Bart., D.C.L., F.R.S., F.G.S. Dr. Lyon Playfair, C.B., M.P., F.R.S. Professor Christison, M.D., D.C.L., Pres. R.S.E. Professor Balfour, F.R.S. L. & E.	Professor A. Crum Brown, M.D., F.R.S.E. J. D. Marwick, Esq., F.R.S.E.

W. B. CARPENTER, Esq., M.D., LL.D., F.R.S., F.L.S. BRIGHTON, August 14, 1872.	The Right Hon. the Earl of Chichester, Lord-Lieutenant of the County of Sussex. His Grace the Duke of Norfolk His Grace the Duke of Richmond, K.G., P.C., D.C.L. His Grace the Duke of Devonshire, K.G., D.C.L., F.G.S. Sir John Lubbock, Bart., M.P., F.R.S., F.L.S., F.G.S. Dr. Sharpey, LL.D., Sec. R.S., F.L.S. Joseph Prestwich, Esq., F.R.S., Pres. G.S.	Charles Carpenter, Esq. The Rev. Dr. Griffith. Henry Willett, Esq.
PROFESSOR ALEXANDER W. WILLIAMSON, Ph.D., F.R.S., F.C.S. BRADFORD, September 17, 1873.	The Right Hon. the Earl of Rosse, F.R.S., F.R.A.S. The Right Hon. Lord Houghton, D.C.L., F.R.S. The Right Hon. W. E. Forster, M.P. The Mayor of Bradford. Sir John Hawkshaw, F.R.S., F.G.S. J. P. Gassiot, Esq., D.C.L. F.R.S. Professor Phillips, D.C.L., F.R.S.	The Rev. J. R. Campbell, D.D. Richard Goddard, Esq. Peile Thompson, Esq.
PROFESSOR J. TYNDALL, D.C.L., LL.D., F.R.S. BELFAST, August 19, 1874.	The Right Hon. the Earl of Enniskillen, D.C.L., F.R.S. The Right Hon. the Earl of Rosse, F.R.S. Sir Richard Wallace, Bart., M.P. The Rev. Dr. Henry. Dr. Andrews, F.R.S. The Rev. Dr. Robinson, F.R.S. Professor Stokes, D.C.L., F.R.S.	W. Quartus Ewart, Esq. Professor G. Fuller, C.E. T. Sinclair, Esq.
SIR JOHN HAWKSHAW, M. Inst. C.E., F.R.S., F.G.S. BRISTOL, August 25, 1875.	The Right Hon. the Earl of Ducie, F.R.S., F.G.S. The Right Hon. Sir Stafford H. Northcote, Bart., C.B., M.P., F.R.S. The Mayor of Bristol Major-General Sir Henry C. Rawlinson, K.C.B., LL.D., F.R.S., F.R.G.S. Dr. W. B. Carpenter, LL.D., F.R.S., F.L.S., F.G.S. W. Sanders, Esq., F.R.S., F.G.S.	W. Lant Carpenter, Esq., B.A., B.Sc., F.C.S. John H. Clarke, Esq.
PROFESSOR THOMAS ANDREWS, M.D., LL.D., F.R.S., Hon. F.R.S.E. GLASGOW, September 6, 1876.	His Grace the Duke of Argyll, K.T., LL.D., F.R.S. L. & E., F.G.S. The Hon. the Lord Provost of Glasgow Sir William Stirling Maxwell, Bart., M.A., M.P. Professor Sir William Thomson, M.A., LL.D., D.C.L., F.R.S. L. & E. Professor Allen Thomson, M.D., LL.D., F.R.S. L. & E. Professor A. C. Ramsay, LL.D., F.R.S., F.G.S. James Young, Esq., F.R.S., F.C.S.	Dr. W. G. Blackie, F.R.G.S. James Grahame, Esq. J. D. Marwick, Esq.
PROFESSOR ALLEN THOMSON, M.D., LL.D., F.R.S. L. & E. PLYMOUTH August 15, 1877.	The Right Hon. the Earl of Mount-Edgcumbe The Right Hon. Lord Blachford, K.C.M.G. William Spottiswoode, Esq., M.A. LL.D., F.R.S., F.R.A.S., F.R.G.S. William Froude, Esq., M.A., C.E., F.R.S. Charles Spence Bate, Esq., F.R.S., F.L.S.	William Adams, Esq. William Square, Esq. Hamilton Whiteford, Esq.
WILLIAM SPOTTISWOODE, Esq., M.A., D.C.L., LL.D., F.R.S., F.R.A.S., F.R.G.S. DUBLIN, August 14, 1878.	The Right Hon. the Lord Mayor of Dublin The Provost of Trinity College, Dublin His Grace the Duke of Abercorn, K.G. The Right Hon. the Earl of Enniskillen, D.C.L., F.R.S., F.G.S. The Right Hon. the Earl of Rosse, B.A., D.C.L., F.R.S., F.R.A.S., M.R.I.A. The Right Hon. Lord O'Hagan, M.R.I.A. Professor G. G. Stokes, M.A., D.C.L., LL.D., Sec. R.S.	Professor R. S. Ball, M.A., F.R.S. James Goff, Esq. John Norwood, Esq., LL.D. Professor G. Sigerson, M.D.

PRESIDENTS.	VICE-PRESIDENTS.	LOCAL SECRETARIES.
PROFESSOR G. J. ALLMAN, M.D., LL.D., F.R.S. L. & E., M.R.I.A., Pres. L.S. SHEFFIELD, August 20, 1879.	His Grace the Duke of Devonshire, K.G., M.A., LL.D., F.R.S., F.R.G.S. The Right Hon. the Earl Fitzwilliam, K.G., F.R.G.S. The Right Hon. the Earl of Wharncliffe, F.R.G.S. W. H. Brittain, Esq. (Master Cutler) Professor T. H. Huxley, Ph.D., LL.D., Sec. R.S., F.L.S., F.G.S. Professor W. Odling, M.B., F.R.S., F.C.S.	H. Clifton Sorby, Esq., LL.D., F.R.S., F.G.S. J. F. Moss, Esq.
ANDREW CROMBIE RAMSAY, Esq., LL.D., F.R.S., V.P.G.S., Director-General of the Geological Survey of the United Kingdom, and of the Museum of Practical Geology. SWANSEA, August 25, 1880.	The Right Hon. the Earl of Jersey The Mayor of Swansea The Hon. Sir W. R. Grove, M.A., D.C.L., F.R.S. H. Hussey Vivian, Esq., M.P., F.G.S. L. Ll. Dillwyn, Esq., M.P., F.L.S., F.G.S. J. Gwyn Jeffreys, Esq., LL.D., F.R.S., F.L.S., Treas. G.S., F.R.G.S.	W. Morgan Esq., Ph.D., F.C.S. James Strick, Esq.
SIR JOHN LUBBOCK, Bart., M.P., D.C.L., LL.D., F.R.S., Pres. L.S., F.G.S. YORK, August 31, 1881.	His Grace the Archbishop of York, D.D., F.R.S. The Right Hon. the Lord Mayor of York The Right Hon. Lord Houghton, D.C.L., F.R.S., F.R.G.S. The Venerable Archdeacon Creyke, M.A. The Hon. Sir W. R. Grove, M.A., D.C.L., F.R.S. Professor G. G. Stokes, M.A., D.C.L., LL.D., Sec. R.S. Sir John Hawkshaw, C.E., F.R.S., F.G.S., F.R.G.S. Allen Thomson, Esq., M.D., LL.D., F.R.S. L. & E. Professor Allman, M.D., LL.D., F.R.S. L. & E., F.L.S.	Rev. Thomas Adams, M.A. Tempest Anderson, Esq., M.D., B.Sc.
C. W. SIEMENS, Esq., D.C.L., LL.D., F.R.S., F.C.S., M.Inst.C.E. SOUTHAMPTON, August 23, 1882.	The Right Hon. the Lord Mount-Temple Captain Sir F. J. Evans, K.C.B., F.R.S., F.R.A.S., F.R.G.S., Hydrographer to the Admiralty F. A. Abel, Esq., C.B., F.R.S., V.P.C.S., Director of the Chemical Establishment of the War Department Professor De Chaumont, M.D., F.R.S. Major-General A. C. Cooke, R.E., C.B., F.R.G.S., Director-General of the Ordnance Survey. Wyndham S. Portal, Esq. Professor Prestwich, M.A., F.R.S., F.G.S., F.C.S. Philip Lutley Sclater, Esq., M.A., Ph.D., F.R.S., F.L.S., F.G.S.	C. W. A. Jellicoe, Esq. John E. Le Feuvre, Esq. Morris Miles, Esq.
ARTHUR CAYLEY, Esq., M.A., D.C.L., LL.D., F.R.S., V.P.R.A.S., Sadlerian Professor of Pure Mathematics in the University of Cambridge. SOUTHPORT, September 19, 1883.	The Right Hon. the Earl of Derby, M.A., LL.D., F.R.S., F.R.G.S. The Right Hon. the Earl of Crawford and Balcarres, LL.D., F.R.S., F.R.A.S. The Right Hon. the Earl of Lathom Principal J. W. Dawson, C.M.G., M.A., LL.D., F.R.S., F.G.S. J. G. Greenwood, Esq., LL.D., Vice-Chancellor of the Victoria University Professor H. E. Roscoe, Ph.D., LL.D., F.R.S., F.C.S.	J. H. Ellis, Esq. Dr. Vernon. T. W. Willis, Esq.

The RIGHT HON. LORD RAYLEIGH, M.A., D.C.L., LL.D., F.R.S., F.R.A.S., F.R.G.S., Professor of Experimental Physics in the University of Cambridge. MONTREAL, August 27, 1884.	His Excellency the Governor-General of Canada, G.C.M.G., LL.D. The Right Hon. Sir John Alexander Macdonald, K.C.B., D.C.L., LL.D. The Right Hon. Sir Lyon Playfair, K.C.B., M.P., Ph.D., LL.D., F.R.S.L. & E., F.C.S. The Hon. Sir Alexander Tilloch Galt, G.C.M.G. The Hon. Sir Charles Tupper, K.C.M.G. Chief Justice Sir A. A. Dorion, C.M.G. Principal Sir William Dawson, C.M.G., M.A., LL.D., F.R S., F.G.S. The Hon. Dr. Chauveau Professor Edward Frankland, M.D., D.C.L., Ph.D., LL.D., F.R.S., F.C.S. W. H. Hingston, Esq., M.D., D.C.L., L.R.C.S.E. Thomas Sterry Hunt, Esq., M.A., D.Sc., LL.D., F.R.S.	S. E. Dawson, Esq. R. A. Ramsay, Esq. S. Rivard, Esq. S. C. Stevenson, Esq. Thos. White, Esq., M.P.
The RIGHT HON. SIR LYON PLAYFAIR, K.C.B., M.P., Ph.D., LL.D., F.R.S. L. & E., F.C.S. ABERDEEN, September 9, 1885.	His Grace the Duke of Richmond and Gordon, K.G., D.C.L., Chancellor of the University of Aberdeen The Right Hon. the Earl of Aberdeen, LL.D., Lord-Lieutenant of Aberdeenshire The Right Hon. the Earl of Crawford and Balcarres, M.A., LL.D., F.R.S., F.R.A.S. James Matthews, Esq., Lord Provost of the City of Aberdeen Professor Sir William Thomson, M.A., LL.D., F.R.S. L. & E., F.R.A.S. Alexander Bain, Esq., M.A., LL.D., Rector of the University of Aberdeen The Very Rev. Principal Pirie, D.D., Vice-Chancellor of the University of Aberdeen Professor W. H. Flower, LL.D., F.R.S., F.L.S., Pres. Z.S., F.G.S., Director of the Natural History Museum, London Professor John Struthers, M.D., LL.D.	J. W. Crombie, Esq., M.A. Angus Fraser, Esq., M.A., M.D., F.C.S. Professor G. Pirie, M.A.
SIR J. WILLIAM DAWSON, C.M.G., M.A., LL.D., F.R.S., F.G.S., Principal and Vice-Chancellor of McGill University, Montreal, Canada BIRMINGHAM, September 1, 1886.	The Right Hon. the Earl of Bradford, Lord-Lieutenant of Shropshire. The Right Hon. Lord Leigh, D.C.L., Lord-Lieutenant of Warwickshire. The Right Hon. Lord Norton, K.C.M.G. The Right Hon. Lord Wrottesley, Lord-Lieutenant of Staffordshire The Right Rev. the Lord Bishop of Worcester, D.D. Thomas Martineau, Esq., Mayor of Birmingham Professor G. G. Stokes, M.A., D.C.L., LL.D., Pres. R.S. Professor W. A. Tilden, D.Sc., F.R.S., F.C.S. Rev. A. R. Vardy, M.A. Rev. H. W. Watson, D.Sc., F.R.S.	J. Barham Carslake, Esq. Rev. H. W. Crosskey, LL.D., F.G.S. Charles J. Hart, Esq.
SIR H. E. ROSCOE, M.P., D.C.L., LL.D., PH.D., F.R.S., V.P.C.S. MANCHESTER, August 31, 1887.	His Grace the Duke of Devonshire, K.G., M.A., LL.D., F.R.S., F.G.S., F.R.G.S. The Right Hon. the Earl of Derby, K.G., M.A., LL.D., F.R.S., F.R.G.S. The Right Rev. the Lord Bishop of Manchester, D.D. The Right Rev. the Bishop of Salford The Right Worshipful the Mayor of Manchester The Right Worshipful the Mayor of Salford The Vice-Chancellor of the Victoria University The Principal of the Owens College Sir William Roberts, B.A., M.D., F.R.S. Thomas Ashton, Esq., J.P., D.L. Oliver Heywood, Esq., J.P., D.L. James Prescott Joule, Esq., D.C.L., LL.D., F.R.S., F.R.S.E., F.C.S.	F. J. Faraday, Esq., F.L.S., F.S.S. Charles Hopkinson, Esq., B.Sc. Professor A. Milnes Marshall, M.A., M.D., D.Sc., F.R.S. Professor A. H. Young, M.B., F.R.C.S.

PRESIDENTS.	VICE-PRESIDENTS.	LOCAL SECRETARIES.
SIR FREDERICK J. BRAMWELL, D.C.L., F.R.S., M.Inst.C.E. BATH, September 5, 1888.	The Right Hon. the Earl of Cork and Orrery, Lord Lieutenant of Somerset The Most Noble the Marquis of Bath The Right Hon. and Right Rev. the Lord Bishop of Bath and Wells, D.D. The Right Rev. the Bishop of Clifton, D.D. The Right Worshipful the Mayor of Bath The Right Worshipful the Mayor of Bristol Sir F. A. Abel, C.B., D.C.L., F.R.S., V.P.C.S. The Venerable the Archdeacon of Bath, M.A. The Rev. Leonard Blomefield, M.A., F.L.S., F.G.S. Professor Michael Foster, M.A., M.D., LL.D., Sec. R.S., F.L.S., F.C.S. W. S. Gore-Langton, Esq., J.P., D.L. H. D. Skrine, Esq., J.P., D.L. E. R. Wodehouse, Esq., M.P. Colonel R. P. Laurie, C.B., M.P. Jerom Murch, Esq., J.P., D.L.	W. Pumphrey, Esq. J. L. Stothert, Esq., M.Inst.C.E. B. H. Watts, Esq.
PROFESSOR WILLIAM HENRY FLOWER, C.B., LL.D., F.R.S., F.R.C.S., Pres.Z.S., F.L.S., F.G.S., Director of the Natural History Departments of the British Museum NEWCASTLE-UPON-TYNE, September 11, 1889.	His Grace the Duke of Northumberland, K.G., D.C.L., LL.D., Lord Lieutenant of Northumberland The Right Hon. the Earl of Durham, Lord Lieutenant of Durham The Right Hon. the Earl of Ravensworth The Right Rev. the Lord Bishop of Newcastle, D.D. The Right Hon. Lord Armstrong, C.B., D.C.L., LL.D., F.R.S. The Right Hon. John Morley, M.P., LL.D. The Very Rev. the Warden of the University of Durham, D.D. The Right Worshipful the Mayor of Newcastle The Worshipful the Mayor of Gateshead Sir I. Lowthian Bell, Bart., D.C.L., F.R.S., F.C.S., M.Inst.C.E. Sir Charles Mark Palmer, Bart., M.P.	Professor P. Phillips Bedson, D.Sc., F.C.S. Professor J. Herman Merivale M.A.

Presidents and Secretaries of the Sections of the Association.

Date and Place	Presidents	Secretaries
MATHEMATICAL AND PHYSICAL SCIENCES.		
COMMITTEE OF SCIENCES, I.—MATHEMATICS AND GENERAL PHYSICS.		
1832. Oxford......	Davies Gilbert, D.C.L., F.R.S.	Rev. H. Coddington.
1833. Cambridge	Sir D. Brewster, F.R.S.	Prof. Forbes.
1834. Edinburgh	Rev. W. Whewell, F.R.S.	Prof. Forbes, Prof. Lloyd.
SECTION A.—MATHEMATICS AND PHYSICS.		
1835. Dublin......	Rev. Dr. Robinson	Prof. Sir W. R. Hamilton, Prof. Wheatstone.
1836. Bristol......	Rev. William Whewell, F.R.S.	Prof. Forbes, W. S. Harris, F. W. Jerrard.
1837. Liverpool...	Sir D. Brewster, F.R.S.	W. S. Harris, Rev. Prof. Powell, Prof. Stevelly.
1838. Newcastle	Sir J. F. W. Herschel, Bart., F.R.S.	Rev. Prof. Chevallier, Major Sabine, Prof. Stevelly.
1839. Birmingham	Rev. Prof. Whewell, F.R.S....	J. D. Chance, W. Snow Harris, Prof. Stevelly.
1840. Glasgow ...	Prof. Forbes, F.R.S............	Rev. Dr. Forbes, Prof. Stevelly, Arch. Smith.
1841. Plymouth	Rev. Prof. Lloyd, F.R.S.......	Prof. Stevelly.
1842. Manchester	Very Rev. G. Peacock, D.D., F.R.S.	Prof. M'Culloch, Prof. Stevelly, Rev. W. Scoresby.
1843. Cork.........	Prof. M'Culloch, M.R.I.A. ...	J. Nott, Prof. Stevelly.
1844. York.........	The Earl of Rosse, F.R.S. ...	Rev. Wm. Hey, Prof. Stevelly.
1845. Cambridge	The Very Rev. the Dean of Ely.	Rev. H. Goodwin, Prof. Stevelly, G. G. Stokes.
1846. Southampton.	Sir John F. W. Herschel, Bart., F.R.S.	John Drew, Dr. Stevelly, G. G. Stokes.
1847. Oxford......	Rev. Prof. Powell, M.A., F.R.S.	Rev. H. Price, Prof. Stevelly, G. G. Stokes.
1848. Swansea ...	Lord Wrottesley, F.R.S.	Dr. Stevelly, G. G. Stokes.
1849. Birmingham	William Hopkins, F.R.S.......	Prof. Stevelly, G. G. Stokes, W. Ridout Wills.
1850. Edinburgh	Prof. J. D. Forbes, F.R.S., Sec. R.S.E.	W. J. Macquorn Rankine, Prof. Smyth, Prof. Stevelly, Prof. G. G. Stokes.
1851. Ipswich ..	Rev. W. Whewell, D.D., F.R.S.	S. Jackson, W. J. Macquorn Rankine, Prof. Stevelly, Prof. G. G. Stokes.
1852. Belfast......	Prof. W. Thomson, M.A., F.R.S. L. & E.	Prof. Dixon, W. J. Macquorn Rankine, Prof. Stevelly, J. Tyndall.
1853. Hull.........	The Very Rev. the Dean of Ely, F.R.S.	B. Blaydes Haworth, J. D. Sollitt, Prof. Stevelly, J. Welsh.
1854. Liverpool...	Prof. G. G. Stokes, M.A., Sec. R.S.	J. Hartnup, H. G. Puckle, Prof. Stevelly, J. Tyndall, J. Welsh.
1855. Glasgow ...	Rev. Prof. Kelland, M.A., F.R.S. L. & E.	Rev. Dr. Forbes, Prof. D. Gray, Prof. Tyndall.
1856. Cheltenham	Rev. R. Walker, M.A., F.R.S.	C. Brooke, Rev. T. A. Southwood, Prof. Stevelly, Rev. J. C. Turnbull.
1857. Dublin......	Rev. T. R. Robinson, D.D., F.R.S., M.R.I.A.	Prof. Curtis, Prof. Hennessy, P. A. Ninnis, W. J. Macquorn Rankine, Prof. Stevelly.
1858. Leeds	Rev. W. Whewell, D.D., V.P.R.S.	Rev. S. Earnshaw, J. P. Hennessy, Prof. Stevelly, H. J. S. Smith, Prof. Tyndall.

Date and Place	Presidents	Secretaries
1859. Aberdeen...	The Earl of Rosse, M.A., K.P., F.R.S.	J. P. Hennessy, Prof. Maxwell, H. J. S. Smith, Prof. Stevelly.
1860. Oxford......	Rev. B. Price, M.A., F.R.S....	Rev. G. C. Bell, Rev. T. Rennison, Prof. Stevelly.
1861. Manchester	G. B. Airy, M.A., D.C.L., F.R.S.	Prof. R. B. Clifton, Prof. H. J. S. Smith, Prof. Stevelly.
1862. Cambridge	Prof. G. G. Stokes, M.A., F.R.S.	Prof. R. B. Clifton, Prof. H. J. S. Smith, Prof. Stevelly.
1863. Newcastle	Prof. W. J. Macquorn Rankine, C.E., F.R.S.	Rev. N. Ferrers, Prof. Fuller, F. Jenkin, Prof. Stevelly, Rev. C. T. Whitley.
1864. Bath.........	Prof. Cayley, M.A., F.R.S., F.R.A.S.	Prof. Fuller, F. Jenkin, Rev. G. Buckle, Prof. Stevelly.
1865. Birmingham	W. Spottiswoode, M.A., F.R.S., F.R.A.S.	Rev. T. N. Hutchinson, F. Jenkin, G. S. Mathews, Prof. H. J. S. Smith, J. M. Wilson.
1866. Nottingham	Prof. Wheatstone, D.C.L., F.R.S.	Fleeming Jenkin, Prof. H. J. S. Smith, Rev. S. N. Swann.
1867. Dundee ...	Prof. Sir W. Thomson, D.C.L., F.R.S.	Rev. G. Buckle, Prof. G. C. Foster, Prof. Fuller, Prof. Swan.
1868. Norwich ...	Prof. J. Tyndall, LL.D., F.R.S.	Prof. G. C. Foster, Rev. R. Harley, R. B. Hayward.
1869. Exeter......	Prof. J. J. Sylvester, LL.D., F.R.S.	Prof. G. C. Foster, R. B. Hayward, W. K. Clifford.
1870. Liverpool...	J. Clerk Maxwell, M.A., LL.D., F.R.S.	Prof. W. G. Adams, W. K. Clifford, Prof. G. C. Foster, Rev. W. Allen Whitworth.
1871. Edinburgh	Prof. P. G. Tait, F.R.S.E. ...	Prof. W. G. Adams, J. T. Bottomley, Prof. W. K. Clifford, Prof. J. D. Everett, Rev. R. Harley.
1872. Brighton ...	W. De La Rue, D.C.L., F.R.S.	Prof. W. K. Clifford, J. W. L. Glaisher, Prof. A. S. Herschel, G. F. Rodwell.
1873. Bradford ...	Prof. H. J. S. Smith, F.R.S.	Prof. W. K. Clifford, Prof. Forbes, J. W. L. Glaisher, Prof. A. S. Herschel.
1874. Belfast......	Rev. Prof. J. H. Jellett, M.A., M.R.I.A.	J. W. L. Glaisher, Prof. Herschel, Randal Nixon, J. Perry, G. F. Rodwell.
1875. Bristol......	Prof. Balfour Stewart, M.A., LL.D., F.R.S.	Prof. W. F. Barrett, J. W. L. Glaisher, C. T. Hudson, G. F. Rodwell.
1876. Glasgow ...	Prof. Sir W. Thomson, M.A., D.C.L., F.R.S.	Prof. W. F. Barrett, J. T. Bottomley, Prof. G. Forbes, J. W. L. Glaisher, T. Muir.
1877. Plymouth...	Prof. G. C. Foster, B.A., F.R.S., Pres. Physical Soc.	Prof. W. F. Barrett, J. T. Bottomley, J. W. L. Glaisher, F. G. Landon.
1878. Dublin......	Rev. Prof. Salmon, D.D., D.C.L., F.R.S.	Prof. J. Casey, G. F. Fitzgerald, J. W. L. Glaisher, Dr. O. J. Lodge.
1879. Sheffield ...	George Johnstone Stoney, M.A., F.R.S.	A. H. Allen, J. W. L. Glaisher, Dr. O. J. Lodge, D. MacAlister.
1880. Swansea ...	Prof. W. Grylls Adams, M.A., F.R.S.	W. E. Ayrton, J. W. L. Glaisher, Dr. O. J. Lodge, D. MacAlister.
1881. York.........	Prof. Sir W. Thomson, M.A., LL.D., D.C.L., F.R.S.	Prof. W. E. Ayrton, Prof. O. J. Lodge, D. MacAlister, Rev. W. Routh.
1882. Southampton.	Rt. Hon. Prof. Lord Rayleigh, M.A., F.R.S.	W. M. Hicks, Prof. O. J. Lodge, D. MacAlister, Rev. G. Richardson.
1883. Southport	Prof. O. Henrici, Ph.D., F.R.S.,	W. M. Hicks, Prof. O. J. Lodge, D. MacAlister, Prof. R. C. Rowe.
1884. Montreal ...	Prof. Sir W. Thomson, M.A., LL.D., D.C.L. F.R.S.	C. Carpmael, W. M. Hicks, Prof. A. Johnson, Prof. O. J. Lodge, Dr. D. MacAlister.

Date and Place	Presidents	Secretaries
1885. Aberdeen...	Prof. G. Chrystal, M.A., F.R.S.E.	R. E. Baynes, R. T. Glazebrook, Prof. W. M. Hicks, Prof. W. Ingram.
1886. Birmingham	Prof. G. H. Darwin, M.A., LL.D., F.R.S.	R. E. Baynes, R. T. Glazebrook, Prof. J. H. Poynting, W. N. Shaw.
1887. Manchester	Prof. Sir R. S. Ball, M.A., LL.D., F.R.S.	R. E. Baynes, R. T. Glazebrook, Prof. H. Lamb, W. N. Shaw.
1888. Bath.........	Prof. G. F. Fitzgerald, M.A., F.R.S.	R. E. Baynes, R. T. Glazebrook, A. Lodge, W. N. Shaw.
1889. Newcastle-upon-Tyne	Capt. W. de W. Abney, C.B., R.E., F.R.S.	R. E. Baynes, R. T. Glazebrook, Prof. A. Lodge, W. N. Shaw, Prof. H. Stroud.

CHEMICAL SCIENCE.

COMMITTEE OF SCIENCES, II.—CHEMISTRY, MINERALOGY.

1832. Oxford......	John Dalton, D.C.L., F.R.S.	James F. W. Johnston.
1833. Cambridge	John Dalton, D.C.L., F.R.S.	Prof. Miller.
1834. Edinburgh	Dr. Hope.........................	Mr. Johnston, Dr. Christison.

SECTION B.—CHEMISTRY AND MINERALOGY.

1835. Dublin......	Dr. T. Thomson, F.R.S.	Dr. Apjohn, Prof. Johnston.
1836. Bristol......	Rev. Prof. Cumming	Dr. Apjohn, Dr. C. Henry, W. Herapath.
1837. Liverpool...	Michael Faraday, F.R.S.......	Prof. Johnston, Prof. Miller, Dr. Reynolds.
1838. Newcastle	Rev. William Whewell, F.R.S.	Prof. Miller, H. L. Pattinson, Thomas Richardson.
1839. Birmingham	Prof. T. Graham, F.R.S.	Dr. Golding Bird, Dr. J. B. Melson.
1840. Glasgow ...	Dr. Thomas Thomson, F.R.S.	Dr. R. D. Thomson, Dr. T. Clark, Dr. L. Playfair.
1841. Plymouth...	Dr. Daubeny, F.R.S.	J. Prideaux, Robert Hunt, W. M. Tweedy.
1842. Manchester	John Dalton, D.C.L., F.R.S.	Dr. L. Playfair, R. Hunt, J. Graham.
1843. Cork.........	Prof. Apjohn, M.R.I.A.........	R. Hunt, Dr. Sweeny.
1844. York.........	Prof. T. Graham, F.R.S.	Dr. L. Playfair, E. Solly, T. H. Barker.
1845. Cambridge	Rev. Prof. Cumming	R. Hunt, J. P. Joule, Prof. Miller, E. Solly.
1846. Southampton	Michael Faraday, D.C.L., F.R.S.	Dr. Miller, R. Hunt, W. Randall.
1847. Oxford......	Rev. W. V. Harcourt, M.A., F.R.S.	B. C. Brodie, R. Hunt, Prof. Solly.
1848. Swansea ...	Richard Phillips, F.R.S.	T. H. Henry, R. Hunt, T. Williams.
1849. Birmingham	John Percy, M.D., F.R.S.......	R. Hunt, G. Shaw.
1850. Edinburgh	Dr. Christison, V.P.R.S.E.	Dr. Anderson, R. Hunt, Dr. Wilson.
1851. Ipswich ...	Prof. Thomas Graham, F.R.S.	T. J. Pearsall, W. S. Ward.
1852. Belfast......	Thomas Andrews, M.D., F.R.S.	Dr. Gladstone, Prof. Hodges, Prof. Ronalds.
1853. Hull	Prof. J. F. W. Johnston, M.A., F.R.S.	H. S. Blundell, Prof. R. Hunt, T. J. Pearsall.
1854. Liverpool	Prof. W. A. Miller, M.D., F.R.S.	Dr. Edwards, Dr. Gladstone, Dr. Price.
1855. Glasgow ...	Dr. Lyon Playfair, C.B., F.R.S.	Prof. Frankland, Dr. H. E. Roscoe.
1856. Cheltenham	Prof. B. C. Brodie, F.R.S. ...	J. Horsley, P. J. Worsley, Prof. Voelcker.
1857. Dublin......	Prof. Apjohn, M.D., F.R.S., M.R.I.A.	Dr. Davy, Dr. Gladstone, Prof. Sullivan.

Date and Place	Presidents	Secretaries
1858. Leeds	Sir J. F. W. Herschel, Bart., D.C.L.	Dr. Gladstone, W. Odling, R. Reynolds.
1859. Aberdeen...	Dr. Lyon Playfair, C.B., F.R.S.	J. S. Brazier, Dr. Gladstone, G. D. Liveing, Dr. Odling.
1860. Oxford......	Prof. B. C. Brodie, F.R.S......	A. Vernon Harcourt, G. D. Liveing, A. B. Northcote.
1861. Manchester	Prof. W. A. Miller, M.D., F.R.S.	A. Vernon Harcourt, G. D. Liveing.
1862. Cambridge	Prof. W. A. Miller, M.D., F.R.S.	H. W. Elphinstone, W. Odling, Prof. Roscoe.
1863. Newcastle	Dr. Alex. W. Williamson, F.R.S.	Prof. Liveing, H. L. Pattinson, J. C. Stevenson.
1864. Bath.........	W. Odling, M.B., F.R.S., F.C.S.	A. V. Harcourt, Prof. Liveing, R. Biggs.
1865. Birmingham	Prof. W. A. Miller, M.D., V.P.R.S.	A. V. Harcourt, H. Adkins, Prof. Wanklyn, A. Winkler Wills.
1866. Nottingham	H. Bence Jones, M.D., F.R.S.	J. H. Atherton, Prof. Liveing, W. J. Russell, J. White.
1867. Dundee ...	Prof. T. Anderson, M.D., F.R.S.E.	A. Crum Brown, Prof. G. D. Liveing, W. J. Russell.
1868. Norwich ...	Prof. E. Frankland, F.R.S., F.C.S.	Dr. A. Crum Brown, Dr. W. J. Russell, F. Sutton.
1869. Exeter	Dr. H. Debus, F.R.S., F.C.S.	Prof. A. Crum Brown, Dr. W. J. Russell, Dr. Atkinson.
1870. Liverpool...	Prof. H. E. Roscoe, B.A., F.R.S., F.C.S.	Prof. A. Crum Brown, A. E. Fletcher, Dr. W. J. Russell.
1871. Edinburgh	Prof. T. Andrews, M.D., F.R.S.	J. T. Buchanan, W. N. Hartley, T. E Thorpe.
1872. Brighton ...	Dr. J. H. Gladstone, F.R.S....	Dr. Mills, W. Chandler Roberts, Dr. W. J. Russell, Dr. T. Wood.
1873. Bradford ...	Prof. W. J. Russell, F.R.S....	Dr. Armstrong, Dr. Mills, W. Chandler Roberts, Dr. Thorpe.
1874. Belfast......	Prof. A. Crum Brown, M.D., F.R.S.E., F.C.S.	Dr. T. Cranstoun Charles, W. Chandler Roberts, Prof. Thorpe.
1875. Bristol	A. G. Vernon Harcourt, M.A., F.R.S., F.C.S.	Dr. H. E. Armstrong, W. Chandler Roberts, W. A. Tilden.
1876. Glasgow ...	W. H. Perkin, F.R.S.	W. Dittmar, W. Chandler Roberts, J. M. Thomson, W. A. Tilden.
1877. Plymouth...	F. A. Abel, F.R.S., F.C.S. ...	Dr. Oxland, W. Chandler Roberts, J. M. Thomson.
1878. Dublin	Prof. Maxwell Simpson, M.D., F.R.S., F.C.S.	W. Chandler Roberts, J. M. Thomson, Dr. C. R. Tichborne, T. Wills.
1879. Sheffield ...	Prof. Dewar, M.A., F.R.S.	H. S. Bell, W. Chandler Roberts, J. M. Thomson.
1880. Swansea ...	Joseph Henry Gilbert, Ph.D., F.R.S.	P. Phillips Bedson, H. B. Dixon, Dr. W. R. Eaton Hodgkinson, J. M. Thomson.
1881. York.........	Prof. A. W. Williamson, Ph.D., F.R.S.	P. Phillips Bedson, H. B. Dixon, T. Gough.
1882. Southampton.	Prof. G. D. Liveing, M.A., F.R.S.	P. Phillips Bedson, H. B. Dixon, J. L. Notter.
1883. Southport	Dr. J. H. Gladstone, F.R.S...	Prof. P. Phillips Bedson, H. B. Dixon, H. Forster Morley.
1884. Montreal ...	Prof. Sir H. E. Roscoe, Ph.D., LL.D., F.R.S.	Prof. P. Phillips Bedson, H. B. Dixon, T. McFarlane, Prof. W. H. Pike.
1885. Aberdeen...	Prof. H. E. Armstrong, Ph.D., F.R.S., Sec. C.S.	Prof. P. Phillips Bedson, H. B. Dixon, H. Forster Morley, Dr. W. J. Simpson.
1886. Birmingham	W. Crookes, F.R.S., V.P.C.S.	Prof. P. Phillips Bedson, H. B. Dixon, H. Forster Morley, W. W. J. Nicol, C. J. Woodward.

Date and Place	Presidents	Secretaries
1887. Manchester	Dr. E. Schunck, F.R.S., F.C.S.	Prof. P. Phillips Bedson, H. Forster Morley, W. Thomson.
1888. Bath.........	Prof. W. A. Tilden, D.Sc., F.R.S., V.P.C.S.	Prof. H. B. Dixon, Dr. H. Forster Morley, R. E. Moyle, Dr. W. W. J. Nicol.
1889. Newcastle-upon-Tyne	Sir I. Lowthian Bell, Bart., D.C.L., F.R.S., F.C.S.	Dr. H. Forster Morley, D. H. Nagel, Dr. W. W. J. Nicol, H. L. Pattinson, jun.

GEOLOGICAL (AND, UNTIL 1851, GEOGRAPHICAL) SCIENCE.

COMMITTEE OF SCIENCES, III.—GEOLOGY AND GEOGRAPHY.

1832. Oxford......	R. I. Murchison, F.R.S.	John Taylor.
1833. Cambridge.	G. B. Greenough, F.R.S.	W. Lonsdale, John Phillips.
1834. Edinburgh.	Prof. Jameson	Prof. Phillips, T. Jameson Torrie, Rev. J. Yates.

SECTION C.—GEOLOGY AND GEOGRAPHY.

1835. Dublin......	R. J. Griffith	Captain Portlock, T. J. Torrie.
1836. Bristol......	Rev. Dr. Buckland, F.R.S.—*Geography*, R. I. Murchison, F.R.S.	William Sanders, S. Stutchbury, T. J. Torrie.
1837. Liverpool...	Rev. Prof. Sedgwick, F.R.S.—*Geography*, G. B. Greenough, F.R.S.	Captain Portlock, R. Hunter.—*Geography*, Captain H. M. Denham, R.N.
1838. Newcastle..	C. Lyell, F.R.S., V.P.G.S.—*Geography*, Lord Prudhoe.	W. C. Trevelyan, Capt. Portlock.—*Geography*, Capt. Washington.
1839. Birmingham	Rev. Dr. Buckland, F.R.S.—*Geography*, G. B. Greenough, F.R.S.	George Lloyd, M.D., H. E. Strickland, Charles Darwin.
1840. Glasgow ...	Charles Lyell, F.R.S.—*Geography*, G. B. Greenough, F.R.S.	W. J. Hamilton, D. Milne, Hugh Murray, H. E. Strickland, John Scoular, M.D.
1841. Plymouth...	H. T. De la Beche, F.R.S. ...	W. J. Hamilton, Edward Moore, M.D., R. Hutton.
1842. Manchester	R. I. Murchison, F.R.S.	E. W. Binney, R. Hutton, Dr. R. Lloyd, H. E. Strickland.
1843. Cork.........	Richard E. Griffith, F.R.S., M.R.I.A.	Francis M. Jennings, H. E. Strickland.
1844. York.........	Henry Warburton, M.P., Pres. Geol. Soc.	Prof. Ansted, E. H. Bunbury.
1845. Cambridge.	Rev. Prof. Sedgwick, M.A., F.R.S.	Rev. J. C. Cumming, A. C. Ramsay, Rev. W. Thorp.
1846. Southampton.	Leonard Horner, F.R.S.—*Geography*, G. B. Greenough, F.R.S.	Robert A. Austen, Dr. J. H. Norton, Prof. Oldham.—*Geography*, Dr. C. T. Beke.
1847. Oxford......	Very Rev. Dr. Buckland, F.R.S.	Prof. Ansted, Prof. Oldham, A. C. Ramsay, J. Ruskin.
1848. Swansea ...	Sir H. T. De la Beche, C.B., F.R.S.	Starling Benson, Prof. Oldham, Prof. Ramsay.
1849. Birmingham	Sir Charles Lyell, F.R.S., F.G.S.	J. Beete Jukes, Prof. Oldham, Prof. A. C. Ramsay.
1850. Edinburgh[1]	Sir Roderick I. Murchison, F.R.S.	A. Keith Johnston, Hugh Miller, Prof. Nicol.

[1] At a meeting of the General Committee held in 1850, it was resolved 'That the subject of Geography be separated from Geology and combined with Ethnology, to constitute a separate Section, under the title of the "Geographical and Ethnological Section,"' for Presidents and Secretaries of which see page lvii.

Date and Place	Presidents	Secretaries
	SECTION C (*continued*).—GEOLOGY.	
1851. Ipswich ...	William Hopkins, M.A., F.R.S.	C. J. F. Bunbury, G. W. Ormerod, Searles Wood.
1852. Belfast......	Lieut.-Col. Portlock, R.E., F.R.S.	James Bryce, James MacAdam, Prof. M'Coy, Prof. Nicol.
1853. Hull	Prof. Sedgwick, F.R.S.........	Prof. Harkness, William Lawton.
1854. Liverpool ..	Prof. Edward Forbes, F.R.S.	John Cunningham, Prof. Harkness, G. W. Ormerod, J. W. Woodall.
1855. Glasgow ...	Sir R. I. Murchison, F.R.S....	James Bryce, Prof. Harkness, Prof. Nicol.
1856. Cheltenham	Prof. A. C. Ramsay, F.R.S....	Rev. P. B. Brodie, Rev. R. Hepworth, Edward Hull, J. Scougall, T. Wright.
1857. Dublin	The Lord Talbot de Malahide	Prof. Harkness, Gilbert Sanders, Robert H. Scott.
1858. Leeds	William Hopkins, M.A., LL.D., F.R.S.	Prof. Nicol, H. C. Sorby, E. W. Shaw.
1859. Aberdeen...	Sir Charles Lyell, LL.D., D.C.L., F.R.S.	Prof. Harkness, Rev. J. Longmuir, H. C. Sorby.
1860. Oxford	Rev. Prof. Sedgwick, LL.D., F.R.S., F.G.S.	Prof. Harkness, Edward Hull, Capt. D. C. L. Woodall.
1861. Manchester	Sir R. I. Murchison, D.C.L., LL.D., F.R.S.	Prof. Harkness, Edward Hull, T. Rupert Jones, G. W. Ormerod.
1862. Cambridge	J. Beete Jukes, M.A., F.R.S.	Lucas Barrett, Prof. T. Rupert Jones, H. C. Sorby.
1863. Newcastle	Prof. Warington W. Smyth, F.R.S., F.G.S.	E. F. Boyd, John Daglish, H. C. Sorby, Thomas Sopwith.
1864. Bath.........	Prof. J. Phillips, LL.D., F.R.S., F.G.S.	W. B. Dawkins, J. Johnston, H. C. Sorby, W. Pengelly.
1865. Birmingham	Sir R. I. Murchison, Bart., K.C.B.	Rev. P. B. Brodie, J. Jones, Rev. E. Myers, H. C. Sorby, W. Pengelly.
1866. Nottingham	Prof. A. C. Ramsay, LL.D., F.R.S.	R. Etheridge, W. Pengelly, T. Wilson, G. H. Wright.
1867. Dundee ...	Archibald Geikie, F.R.S., F.G.S.	Edward Hull, W. Pengelly, Henry Woodward.
1868. Norwich ...	R. A. C. Godwin-Austen, F.R.S., F.G.S.	Rev. O. Fisher, Rev. J. Gunn, W. Pengelly, Rev. H. H. Winwood.
1869. Exeter	Prof. R. Harkness, F.R.S., F.G.S.	W. Pengelly, W. Boyd Dawkins, Rev. H. H. Winwood.
1870. Liverpool...	Sir Philip de M. Grey Egerton, Bart., M.P., F.R.S.	W. Pengelly, Rev. H. H. Winwood, W. Boyd Dawkins, G. H. Morton.
1871. Edinburgh	Prof. A. Geikie, F.R.S., F.G.S.	R. Etheridge, J. Geikie, T. McKenny Hughes, L. C. Miall.
1872. Brighton ...	R. A. C. Godwin-Austen, F.R.S., F.G.S.	L. C. Miall, George Scott, William Topley, Henry Woodward.
1873. Bradford ...	Prof. J. Phillips, D.C.L., F.R.S., F.G.S.	L. C. Miall, R. H. Tiddeman, W. Topley.
1874. Belfast......	Prof. Hull, M.A., F.R.S., F.G.S.	F. Drew, L. C. Miall, R. G. Symes, R. H. Tiddeman.
1875. Bristol	Dr. Thomas Wright, F.R.S.E., F.G.S.	L. C. Miall, E. B. Tawney, W. Topley.
1876. Glasgow ..	Prof. John Young, M.D.	J. Armstrong, F. W. Rudler, W. Topley.
1877. Plymouth...	W. Pengelly, F.R.S., F.G.S.	Dr. Le Neve Foster, R. H. Tiddeman, W. Topley.
1878. Dublin......	John Evans, D.C.L., F.R.S., F.S.A., F.G.S.	E. T. Hardman, Prof. J. O'Reilly, R. H. Tiddeman.
1879. Sheffield ...	Prof. P. Martin Duncan, M.B., F.R.S., F.G.S.	W. Topley, G. Blake Walker.

Date and Place	Presidents	Secretaries
1880. Swansea ...	H. C. Sorby, LL.D., F.R.S., F.G.S.	W. Topley, W. Whitaker.
1881. York.........	A. C. Ramsay, LL.D., F.R.S., F.G.S.	J. E. Clark, W. Keeping, W. Topley, W. Whitaker.
1882. Southampton.	R. Etheridge, F.R.S., F.G.S.	T. W. Shore, W. Topley, E. Westlake, W. Whitaker.
1883. Southport	Prof. W. C. Williamson, LL.D., F.R.S.	R. Betley, C. E. De Rance, W. Topley, W. Whitaker.
1884. Montreal ...	W. T. Blanford, F.R S., Sec. G.S.	F. Adams, Prof. E. W. Claypole, W. Topley, W. Whitaker.
1885. Aberdeen ...	Prof. J. W. Judd, F.R.S., Sec. G.S.	C. E. De Rance, J. Horne, J. J. H. Teall, W. Topley.
1886. Birmingham	Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., F.G.S.	W. J. Harrison, J. J. H. Teall, W. Topley, W. W. Watts.
1887. Manchester	Henry Woodward, LL.D., F.R.S., F.G.S.	J. E. Marr, J. J. H. Teall, W. Topley, W. W. Watts.
1888. Bath.........	Prof. W. Boyd Dawkins, M.A., F.R.S., F.G.S.	Prof. G. A. Lebour, W. Topley, W. W. Watts, H. B. Woodward.
1889. Newcastle-upon-Tyne	Prof. J. Geikie, LL.D., D.C.L., F.R.S., F.G.S.	Prof. G. A. Lebour, J. E. Marr, W. W. Watts, H. B. Woodward.

BIOLOGICAL SCIENCES.

COMMITTEE OF SCIENCES, IV.—ZOOLOGY, BOTANY, PHYSIOLOGY, ANATOMY.

1832. Oxford......	Rev. P. B. Duncan, F.G.S. ...	Rev. Prof. J. S. Henslow.
1833. Cambridge[1]	Rev. W. L. P. Garnons, F.L.S.	C. C. Babington, D. Don.
1834. Edinburgh.	Prof. Graham.....................	W. Yarrell, Prof. Burnett.

SECTION D.—ZOOLOGY AND BOTANY.

1835. Dublin......	Dr. Allman........................	J. Curtis, Dr. Litton.
1836. Bristol......	Rev. Prof. Henslow	J. Curtis, Prof. Don, Dr. Riley, S. Rootsey.
1837. Liverpool...	W. S. MacLeay..................	C. C. Babington, Rev. L. Jenyns, W. Swainson.
1838. Newcastle	Sir W. Jardine, Bart.	J. E. Gray, Prof. Jones, R. Owen, Dr. Richardson.
1839. Birmingham	Prof. Owen, F.R.S	E. Forbes, W. Ick, R. Patterson.
1840. Glasgow ...	Sir W. J. Hooker, LL.D.......	Prof. W. Couper, E. Forbes, R. Patterson.
1841. Plymouth...	John Richardson, M.D., F.R.S.	J. Couch, Dr. Lankester, R. Patterson.
1842. Manchester	Hon. and Very Rev. W. Herbert, LL.D., F.L.S.	Dr. Lankester, R. Patterson, J. A. Turner.
1843. Cork.........	William Thompson, F.L.S....	G. J. Allman, Dr. Lankester, R. Patterson.
1844. York.........	Very Rev. the Dean of Manchester.	Prof. Allman, H. Goodsir, Dr. King, Dr. Lankester.
1845. Cambridge	Rev. Prof. Henslow, F.L.S....	Dr. Lankester, T. V. Wollaston.
1846. Southampton.	Sir J. Richardson, M.D., F.R.S.	Dr. Lankester, T. V. Wollaston, H. Wooldridge.
1847. Oxford......	H. E. Strickland, M.A., F.R.S.	Dr. Lankester, Dr. Melville, T. V. Wollaston.

[1] At this Meeting Physiology and Anatomy were made a separate Committee, for Presidents and Secretaries of which see p. lvi.

Date and Place	Presidents	Secretaries

SECTION D (*continued*).—ZOOLOGY AND BOTANY, INCLUDING PHYSIOLOGY.

[For the Presidents and Secretaries of the Anatomical and Physiological Subsections and the temporary Section E of Anatomy and Medicine, see p. lvi.]

1848. Swansea ...	L. W. Dillwyn, F.R.S.	Dr. R. Wilbraham Falconer, A. Henfrey, Dr. Lankester.
1849. Birmingham	William Spence, F.R.S.	Dr. Lankester, Dr. Russell.
1850. Edinburgh	Prof. Goodsir, F.R.S. L. & E.	Prof. J. H. Bennett, M.D., Dr. Lankester, Dr. Douglas Maclagan.
1851. Ipswich ...	Rev. Prof. Henslow, M.A., F.R.S.	Prof. Allman, F. W. Johnston, Dr. E. Lankester.
1852. Belfast......	W. Ogilby	Dr. Dickie, George C. Hyndman, Dr. Edwin Lankester.
1853. Hull	C. C. Babington, M.A., F.R.S.	Robert Harrison, Dr. E. Lankester.
1854. Liverpool...	Prof. Balfour, M.D., F.R.S....	Isaac Byerley, Dr. E. Lankester.
1855. Glasgow ...	Rev. Dr. Fleeming, F.R.S.E.	William Keddie, Dr. Lankester.
1856. Cheltenham	Thomas Bell, F.R.S., Pres.L.S.	Dr. J. Abercrombie, Prof. Buckman, Dr. Lankester.
1857. Dublin	Prof. W. H. Harvey, M.D., F.R.S.	Prof. J. R. Kinahan, Dr. E. Lankester, Robert Patterson, Dr. W. E. Steele.
1858. Leeds	C. C. Babington, M.A., F.R.S.	Henry Denny, Dr. Heaton, Dr. E. Lankester, Dr. E. Perceval Wright.
1859. Aberdeen...	Sir W. Jardine, Bart., F.R.S.E.	Prof. Dickie, M.D., Dr. E. Lankester, Dr. Ogilvy.
1860. Oxford	Rev. Prof. Henslow, F.L.S....	W. S. Church, Dr. E. Lankester, P. L. Sclater, Dr. E. Perceval Wright.
1861. Manchester	Prof. C. C. Babington, F.R.S.	Dr. T. Alcock, Dr. E. Lankester, Dr. P. L. Sclater, Dr. E. P. Wright.
1862. Cambridge	Prof. Huxley, F.R.S.	Alfred Newton, Dr. E. P. Wright.
1863. Newcastle	Prof. Balfour, M.D., F.R.S....	Dr. E. Charlton, A. Newton, Rev. H. B. Tristram, Dr. E. P. Wright.
1864. Bath	Dr. John E. Gray, F.R.S. ...	H. B. Brady, C. E. Broom, H. T. Stainton, Dr. E. P. Wright.
1865. Birmingham	T. Thomson, M.D., F.R.S. ...	Dr. J. Anthony, Rev. C. Clarke, Rev. H. B. Tristram, Dr. E. P. Wright.

SECTION D (*continued*).—BIOLOGY.[1]

1866. Nottingham	Prof. Huxley, LL.D., F.R.S. —*Physiological Dep.*, Prof. Humphry, M.D., F.R.S.—*Anthropological Dep.*, Alf. R. Wallace, F.R.G.S.	Dr. J. Beddard, W. Felkin, Rev. H. B. Tristram, W. Turner, E. B. Tylor, Dr. E. P. Wright.
1867. Dundee ...	Prof. Sharpey, M.D., Sec. R.S. —*Dep. of Zool. and Bot.*, George Busk, M.D., F.R.S.	C. Spence Bate, Dr. S. Cobbold, Dr. M. Foster, H. T. Stainton, Rev. H. B. Tristram, Prof. W. Turner.
1868. Norwich ...	Rev. M. J. Berkeley, F.L.S. —*Dep. of Physiology*, W. H. Flower, F.R.S.	Dr. T. S. Cobbold, G. W. Firth, Dr. M. Foster, Prof. Lawson, H. T. Stainton, Rev. Dr. H. B. Tristram, Dr. E. P. Wright.
1869. Exeter	George Busk, F.R.S., F.L.S. —*Dep. of Bot. and Zool.*, C. Spence Bate, F.R.S.—*Dep. of Ethno.*, E. B. Tylor.	Dr. T. S. Cobbold, Prof. M. Foster, E. Ray Lankester, Prof. Lawson, H. T. Stainton, Rev. H. B. Tristram.

[1] At a meeting of the General Committee in 1865, it was resolved:—'That the title of Section D be changed to Biology;' and 'That for the word "Subsection," in the rules for conducting the business of the Sections, the word "Department" be substituted.'

Date and Place	Presidents	Secretaries
1870. Liverpool...	Prof. G. Rolleston, M.A., M.D., F.R.S., F.L.S.—*Dep. of Anat. and Physiol.*, Prof. M. Foster, M.D., F.L.S.—*Dep. of Ethno.*, J. Evans, F.R.S.	Dr. T. S. Cobbold, Sebastian Evans, Prof. Lawson, Thos. J. Moore, H. T. Stainton, Rev. H. B. Tristram, C. Staniland Wake, E. Ray Lankester.
1871. Edinburgh.	Prof. Allen Thomson, M.D., F.R.S.—*Dep. of Bot. and Zool.*, Prof. Wyville Thomson, F.R.S.—*Dep. of Anthropol.*, Prof. W. Turner, M.D.	Dr. T. R. Fraser, Dr. Arthur Gamgee, E. Ray Lankester, Prof. Lawson, H. T. Stainton, C. Staniland Wake, Dr. W. Rutherford, Dr. Kelburne King.
1872. Brighton ...	Sir J. Lubbock, Bart., F.R.S.—*Dep. of Anat. and Physiol.*, Dr. Burdon Sanderson, F.R.S.—*Dep. of Anthropol.*, Col. A. Lane Fox, F.G.S.	Prof. Thiselton-Dyer, H. T. Stainton, Prof. Lawson, F. W. Rudler, J. H. Lamprey, Dr. Gamgee, E. Ray Lankester, Dr. Pye-Smith.
1873. Bradford ...	Prof. Allman, F.R.S.—*Dep. of Anat. and Physiol.*, Prof. Rutherford, M.D.—*Dep. of Anthropol.*, Dr. Beddoe, F.R.S.	Prof. Thiselton-Dyer, Prof. Lawson, R. M'Lachlan, Dr. Pye-Smith, E. Ray Lankester, F. W. Rudler, J. H. Lamprey.
1874. Belfast	Prof. Redfern, M.D.—*Dep. of Zool. and Bot.*, Dr. Hooker, C.B., Pres. R.S.—*Dep. of Anthrop.*, Sir W. R. Wilde, M.D.	W. T. Thiselton-Dyer, R. O. Cunningham, Dr. J. J. Charles, Dr. P. H. Pye-Smith, J. J. Murphy, F. W. Rudler.
1875. Bristol	P. L. Sclater, F.R.S.—*Dep. of Anat. and Physiol.*, Prof. Cleland, M.D., F.R.S.—*Dep. of Anthropol.*, Prof. Rolleston, M.D., F.R.S.	E. R. Alston, Dr. McKendrick, Prof. W. R. M'Nab, Dr. Martyn, F. W. Rudler, Dr. P. H. Pye-Smith, Dr. W. Spencer.
1876. Glasgow ...	A. Russel Wallace, F.R.G.S., F.L.S.—*Dep. of Zool. and Bot.*, Prof. A. Newton, M.A., F.R.S.—*Dep. of Anat. and Physiol.*, Dr. J. G. McKendrick, F.R.S.E.	E. R. Alston, Hyde Clarke, Dr. Knox, Prof. W. R. M'Nab, Dr. Muirhead, Prof. Morrison Watson.
1877. Plymouth...	J. Gwyn Jeffreys, LL.D., F.R.S., F.L.S.—*Dep. of Anat. and Physiol.*, Prof. Macalister, M.D.—*Dep. of Anthropol.*, Francis Galton, M.A., F.R.S.	E. R. Alston, F. Brent, Dr. D. J. Cunningham, Dr. C. A. Hingston, Prof. W. R. M'Nab, J. B. Rowe, F. W. Rudler.
1878. Dublin	Prof. W. H. Flower, F.R.S.—*Dep. of Anthropol.*, Prof. Huxley, Sec. R.S.—*Dep. of Anat. and Physiol.*, R. McDonnell, M.D., F.R.S.	Dr. R. J. Harvey, Dr. T. Hayden, Prof. W. R. M'Nab, Prof. J. M. Purser, J. B. Rowe, F. W. Rudler.
1879. Sheffield ...	Prof. St. George Mivart, F.R.S.—*Dep. of Anthropol.*, E. B. Tylor, D.C.L., F.R.S.—*Dep. of Anat. and Physiol.*, Dr. Pye-Smith.	Arthur Jackson, Prof. W. R. M'Nab, J. B. Rowe, F. W. Rudler, Prof. Schäfer.
1880. Swansea ...	A. C. L. Günther, M.D., F.R.S.—*Dep. of Anat. and Physiol.*, F. M. Balfour, M.A., F.R.S.—*Dep. of Anthropol.*, F. W. Rudler, F.G.S.	G. W. Bloxam, John Priestley, Howard Saunders, Adam Sedgwick.
1881. York.........	Richard Owen, C.B., M.D., F.R.S.—*Dep. of Anthropol.*, Prof. W. H. Flower, LL.D., F.R.S.—*Dep. of Anat. and Physiol.*, Prof. J. S. Burdon Sanderson, M.D., F.R.S.	G. W. Bloxam, W. A. Forbes, Rev. W. C. Hey, Prof. W. R. M'Nab, W. North, John Priestley, Howard Saunders, H. E. Spencer.

Date and Place	Presidents	Secretaries
1882. Southampton.	Prof. A. Gamgee, M.D., F.R.S. —*Dep. of Zool. and Bot.*, Prof. M. A. Lawson, M.A., F.L.S.—*Dep. of Anthropol.*, Prof. W. Boyd Dawkins, M.A., F.R.S.	G. W. Bloxam, W. Heape, J. B. Nias, Howard Saunders, A. Sedgwick, T. W. Shore, jun.
1883. Southport[1]	Prof. E. Ray Lankester, M.A., F.R.S.—*Dep. of Anthropol.*, W. Pengelly, F.R.S.	G. W. Bloxam, Dr. G. J. Haslam, W. Heape, W. Hurst, Prof. A. M. Marshall, Howard Saunders, Dr. G. A. Woods.
1884. Montreal[2]...	Prof. H. N. Moseley, M.A., F.R.S.	Prof. W. Osler, Howard Saunders, A. Sedgwick, Prof. R. R. Wright.
1885. Aberdeen ...	Prof. W. C. McIntosh, M.D., LL.D., F.R.S. L. & E.	W. Heape, J. McGregor-Robertson, J. Duncan Matthews, Howard Saunders, H. Marshall Ward.
1886. Birmingham	W. Carruthers, Pres. L.S., F.R.S., F.G.S.	Prof. T. W. Bridge, W. Heape, Prof. W. Hillhouse, W. L. Sclater, Prof. H. Marshall Ward.
1887. Manchester	Prof. A. Newton, M.A., F.R.S., F.L.S., V.P.Z.S.	C. Bailey, F. E. Beddard, S. F. Harmer, W. Heape, W. L. Sclater, Prof. H. Marshall Ward.
1888. Bath.........	W. T. Thiselton-Dyer, C.M.G., F.R.S., F.L.S.	F. E. Beddard, S. F. Harmer, Prof. H. Marshall Ward, W. Gardiner, Prof. W. D. Halliburton.
1889. Newcastle-upon-Tyne	Prof. J. S. Burdon Sanderson, M.A., M.D., F.R.S.	C. Bailey, F. E. Beddard, S. F. Harmer, Prof. T. Oliver, Prof. H. Marshall Ward.

ANATOMICAL AND PHYSIOLOGICAL SCIENCES.

COMMITTEE OF SCIENCES, V.—ANATOMY AND PHYSIOLOGY.

1833. Cambridge	Dr. Haviland......................	Dr. Bond, Mr. Paget.
1834. Edinburgh	Dr. Abercrombie	Dr. Roget, Dr. William Thomson.

SECTION E (UNTIL 1847).—ANATOMY AND MEDICINE.

1835. Dublin	Dr. Pritchard......................	Dr. Harrison, Dr. Hart.
1836. Bristol	Dr. Roget, F.R.S.	Dr. Symonds.
1837. Liverpool...	Prof. W. Clark, M.D.	Dr. J. Carson, jun., James Long, Dr. J. R. W. Vose.
1838. Newcastle	T. E. Headlam, M.D.	T. M. Greenhow, Dr. J. R. W. Vose.
1839. Birmingham	John Yelloly, M.D., F.R.S....	Dr. G. O. Rees, F. Ryland.
1840. Glasgow ...	James Watson, M.D.	Dr. J. Brown, Prof. Couper, Prof. Reid.

SECTION E.—PHYSIOLOGY.

1841. Plymouth...	P. M. Roget, M.D., Sec. R.S.	Dr. J. Butter, J. Fuge, Dr. R. S. Sargent.
1842. Manchester	Edward Holme, M.D., F.L.S.	Dr. Chaytor, Dr. R. S. Sargent.
1843. Cork	Sir James Pitcairn, M.D. ...	Dr. John Popham, Dr. R. S. Sargent.
1844. York	J. C. Pritchard, M.D.	I. Erichsen, Dr. R. S. Sargent.

[1] By direction of the General Committee at Southampton (1882) the Departments of Zoology and Botany and of Anatomy and Physiology were amalgamated.

[2] By authority of the General Committee, Anthropology was made a separate Section, for Presidents and Secretaries of which see p. lxii.

Date and Place	Presidents	Secretaries
1845. Cambridge	Prof. J. Haviland, M.D.	Dr. R. S. Sargent, Dr. Webster.
1846. Southampton.	Prof. Owen, M.D., F.R.S. ...	C. P. Keele, Dr. Laycock, Dr. Sargent.
1847. Oxford[1] ...	Prof. Ogle, M.D., F.R.S.	Dr. Thomas K. Chambers, W. P. Ormerod.

PHYSIOLOGICAL SUBSECTIONS OF SECTION D.

1850. Edinburgh	Prof. Bennett, M.D., F.R.S.E.	
1855. Glasgow ...	Prof. Allen Thomson, F.R.S.	Prof. J. H. Corbett, Dr. J. Struthers.
1857. Dublin......	Prof. R. Harrison, M.D.	Dr. R. D. Lyons, Prof. Redfern.
1858. Leeds	Sir Benjamin Brodie, Bart., F.R.S.	C. G. Wheelhouse.
1859. Aberdeen...	Prof. Sharpey, M.D., Sec.R.S.	Prof. Bennett, Prof. Redfern.
1860. Oxford......	Prof.G.Rolleston,M.D.,F.L.S.	Dr. R. M'Donnell, Dr. Edward Smith.
1861. Manchester	Dr. John Davy, F.R.S.L.& E.	Dr. W. Roberts, Dr. Edward Smith.
1862. Cambridge	G. E. Paget, M.D................	G. F. Helm, Dr. Edward Smith.
1863. Newcastle	Prof. Rolleston, M.D., F.R.S.	Dr. D. Embleton, Dr. W. Turner.
1864. Bath.........	Dr. Edward Smith, LL.D., F.R.S.	J. S. Bartrum, Dr. W. Turner.
1865. Birmingham.[2]	Prof. Acland, M.D., LL.D., F.R.S.	Dr. A. Fleming, Dr. P. Heslop, Oliver Pembleton, Dr. W. Turner.

GEOGRAPHICAL AND ETHNOLOGICAL SCIENCES.

[For Presidents and Secretaries for Geography previous to 1851, see Section C. p. li.]

ETHNOLOGICAL SUBSECTIONS OF SECTION D.

1846.Southampton	Dr. Pritchard.....................	Dr. King.
1847. Oxford	Prof. H. H. Wilson, M.A. ...	Prof. Buckley.
1848. Swansea ...	....	G. Grant Francis.
1849. Birmingham	....	Dr. R. G. Latham.
1850. Edinburgh	Vice-Admiral Sir A. Malcolm	Daniel Wilson.

SECTION E.—GEOGRAPHY AND ETHNOLOGY.

1851. Ipswich ...	Sir R. I. Murchison, F.R.S., Pres. R.G.S.	R. Cull, Rev. J. W. Donaldson, Dr. Norton Shaw.
1852. Belfast......	Col. Chesney, R.A., D.C.L., F.R.S.	R. Cull, R. MacAdam, Dr. Norton Shaw.
1853. Hull.........	R. G. Latham, M.D., F.R.S.	R. Cull, Rev. H. W. Kemp, Dr. Norton Shaw.
1854. Liverpool...	Sir R. I. Murchison, D.C.L., F.R.S.	Richard Cull, Rev. H. Higgins, Dr. Ihne, Dr. Norton Shaw.
1855. Glasgow ...	Sir J. Richardson, M.D., F.R.S.	Dr. W. G. Blackie, R. Cull, Dr. Norton Shaw.
1856. Cheltenham	Col. Sir H. C. Rawlinson, K.C.B.	R. Cull, F. D. Hartland, W. H. Rumsey, Dr. Norton Shaw.
1857. Dublin......	Rev. Dr. J. Henthorn Todd, Pres. R.I.A.	R. Cull, S. Ferguson, Dr. R. R. Madden, Dr. Norton Shaw.

[1] By direction of the General Committee at Oxford, Sections D and E were incorporated under the name of 'Section D—Zoology and Botany, including Physiology' (see p. liv.). The Section being then vacant was assigned in 1851 to Geography.

[2] *Vide* note on page liv.

Date and Place	Presidents	Secretaries
1858. Leeds	Sir R. I. Murchison, G.C.St.S., F.R.S.	R. Cull, Francis Galton, P. O'Callaghan, Dr. Norton Shaw, Thomas Wright.
1859. Aberdeen...	Rear - Admiral Sir James Clerk Ross, D.C.L., F.R.S.	Richard Cull, Prof. Geddes, Dr. Norton Shaw.
1860. Oxford......	Sir R. I. Murchison, D.C.L., F.R.S.	Capt. Burrows, Dr. J. Hunt, Dr. C. Lemprière, Dr. Norton Shaw.
1861. Manchester	John Crawfurd, F.R.S..........	Dr. J. Hunt, J. Kingsley, Dr. Norton Shaw, W. Spottiswoode.
1862. Cambridge	Francis Galton, F.R.S..........	J.W.Clarke, Rev. J. Glover, Dr. Hunt, Dr. Norton Shaw, T. Wright.
1863. Newcastle	Sir R. I. Murchison, K.C.B., F.R.S.	C. Carter Blake, Hume Greenfield, C. R. Markham, R. S. Watson.
1864. Bath.........	Sir R. I. Murchison, K.C.B., F.R.S.	H. W. Bates, C. R. Markham, Capt. R. M. Murchison, T. Wright.
1865. Birmingham	Major-General Sir H. Rawlinson, M.P., K.C.B., F.R.S.	H. W. Bates, S. Evans, G. Jabet, C. R. Markham, Thomas Wright.
1866. Nottingham	Sir Charles Nicholson, Bart., LL.D.	H. W. Bates, Rev. E. T. Cusins, R. H. Major, Clements R. Markham, D. W. Nash, T. Wright.
1867. Dundee ...	Sir Samuel Baker, F.R.G.S.	H. W. Bates, Cyril Graham, Clements R. Markham, S. J. Mackie, R. Sturrock.
1868. Norwich ...	Capt. G. H. Richards, R.N., F.R.S.	T. Baines, H. W. Bates, Clements R. Markham, T. Wright.

SECTION E (*continued*).—GEOGRAPHY.

1869. Exeter	Sir Bartle Frere, K.C.B., LL.D., F.R.G.S.	H. W. Bates, Clements R. Markham J. H. Thomas.
1870. Liverpool...	Sir R. I. Murchison, Bt., K.C.B., LL.D., D.C.L., F.R.S., F.G.S.	H.W.Bates, David Buxton, Albert J. Mott, Clements R. Markham.
1871. Edinburgh	Colonel Yule, C.B., F.R.G.S.	A. Buchan, A. Keith Johnston, Clements R. Markham, J. H. Thomas.
1872. Brighton ...	Francis Galton, F.R.S..........	H. W. Bates, A. Keith Johnston, Rev. J. Newton, J. H. Thomas.
1873. Bradford ...	Sir Rutherford Alcock, K.C.B.	H. W. Bates, A. Keith Johnston, Clements R. Markham.
1874. Belfast......	Major Wilson, R.E., F.R.S., F.R.G.S.	E. G. Ravenstein, E. C. Rye, J. H. Thomas.
1875. Bristol	Lieut. - General Strachey, R.E., C.S.I., F.R.S., F.R.G.S., F.L.S., F.G.S.	H. W. Bates, E. C. Rye, F. F. Tuckett.
1876. Glasgow ...	Capt. Evans, C.B., F.R.S.......	H. W. Bates, E. C. Rye, R. Oliphant Wood.
1877. Plymouth...	Adm. Sir E. Ommanney, C.B., F.R.S., F.R.G.S., F.R.A.S.	H. W. Bates, F. E. Fox, E. C. Rye.
1878. Dublin......	Prof. Sir C. Wyville Thomson, LL.D., F.R.S.L.&E.	John Coles, E. C. Rye.
1879. Sheffield ...	Clements R. Markham, C.B., F.R.S., Sec. R.G.S.	H. W. Bates, C. E. D. Black, E. C. Rye.
1880. Swansea ...	Lieut.-Gen. Sir J. H. Lefroy, C.B., K.C.M.G., R.A., F.R.S., F.R.G.S.	H. W. Bates, E. C. Rye.
1881. York.........	Sir J. D. Hooker, K.C.S.I., C.B., F.R.S.	J. W. Barry, H. W. Bates.
1882. Southampton.	Sir R. Temple, Bart., G.C.S.I., F.R.G.S.	E. G. Ravenstein, E. C. Rye.
1883. Southport	Lieut.-Col. H. H. Godwin-Austen, F.R.S.	John Coles, E. G. Ravenstein, E. C. Rye.

Date and Place	Presidents	Secretaries
1884. Montreal ...	Gen. Sir J. H. Lefroy, C.B., K.C.M.G., F.R.S., V.P.R.G.S.	Rev. Abbé Laflamme, J. S. O'Halloran, E. G. Ravenstein, J. F. Torrance.
1885. Aberdeen...	Gen. J. T. Walker, C.B., R.E., LL.D., F.R.S.	J. S. Keltie, J. S. O'Halloran, E. G. Ravenstein, Rev. G. A. Smith.
1886. Birmingham	Maj.-Gen. Sir. F. J. Goldsmid, K.C.S.I., C.B., F.R.G.S.	F. T. S. Houghton, J. S. Keltie, E. G. Ravenstein.
1887. Manchester	Col. Sir C. Warren, R.E., G.C.M.G., F.R.S., F.R.G.S.	Rev. L. C. Casartelli, J. S. Keltie, H. J. Mackinder, E. G. Ravenstein.
1888. Bath.........	Col. Sir C. W. Wilson, R.E., K.C.B., F.R.S., F.R.G.S.	J. S. Keltie, H. J. Mackinder, E. G. Ravenstein.
1889. Newcastle-upon-Tyne	Col. Sir F. de Winton, K.C.M.G., C.B., F.R.G.S.	J. S. Keltie, H. J. Mackinder, R. Sulivan, A. Silva White.

STATISTICAL SCIENCE.

COMMITTEE OF SCIENCES, VI.—STATISTICS.

1833. Cambridge	Prof. Babbage, F.R.S.	J. E. Drinkwater.
1834. Edinburgh	Sir Charles Lemon, Bart.......	Dr. Cleland, C. Hope Maclean.

SECTION F.—STATISTICS.

1835. Dublin	Charles Babbage, F.R.S.	W. Greg, Prof. Longfield.
1836. Bristol	Sir Chas. Lemon, Bart., F.R.S.	Rev. J. E. Bromby, C. B. Fripp, James Heywood.
1837. Liverpool...	Rt. Hon. Lord Sandon	W. R. Greg, W. Langton, Dr. W. C. Tayler.
1838. Newcastle	Colonel Sykes, F.R.S.	W. Cargill, J. Heywood, W. R. Wood.
1839. Birmingham	Henry Hallam, F.R.S.	F. Clarke, R. W. Rawson, Dr. W. C. Tayler.
1840. Glasgow ...	Rt. Hon. Lord Sandon, M.P., F.R.S.	C. R. Baird, Prof. Ramsay, R. W. Rawson.
1841. Plymouth...	Lieut.-Col. Sykes, F.R.S.......	Rev. Dr. Byrth, Rev. R. Luney, R. W. Rawson.
1842. Manchester	G. W. Wood, M.P., F.L.S. ...	Rev. R. Luney, G. W. Ormerod, Dr. W. C. Tayler.
1843. Cork	Sir C. Lemon, Bart., M.P. ...	Dr. D. Bullen, Dr. W. Cooke Tayler.
1844. York.........	Lieut.-Col. Sykes, F.R.S., F.L.S.	J. Fletcher, J. Heywood, Dr. Laycock.
1845. Cambridge	Rt. Hon. the Earl Fitzwilliam	J. Fletcher, Dr. W. Cooke Tayler.
1846. Southampton.	G. R. Porter, F.R.S.	J. Fletcher, F. G. P. Neison, Dr. W. C. Tayler, Rev. T. L. Shapcott.
1847. Oxford	Travers Twiss, D.C.L., F.R.S.	Rev. W. H. Cox, J. J. Danson, F. G. P. Neison.
1848. Swansea ...	J. H. Vivian, M.P., F.R.S. ...	J. Fletcher, Capt. R. Shortrede.
1849. Birmingham	Rt. Hon. Lord Lyttelton......	Dr. Finch, Prof. Hancock, F. G. P. Neison.
1850. Edinburgh	Very Rev. Dr. John Lee, V.P.R.S.E.	Prof. Hancock, J. Fletcher, Dr. J. Stark.
1851. Ipswich ...	Sir John P. Boileau, Bart. ...	J. Fletcher, Prof. Hancock.
1852. Belfast......	His Grace the Archbishop of Dublin.	Prof. Hancock, Prof. Ingram, James MacAdam, jun.
1853. Hull	James Heywood, M.P., F.R.S.	Edward Cheshire, W. Newmarch.
1854. Liverpool...	Thomas Tooke, F.R.S.	E. Cheshire, J. T. Danson, Dr. W. H. Duncan, W. Newmarch.
1855. Glasgow ...	R. Monckton Milnes, M.P. ...	J. A. Campbell, E. Cheshire, W. Newmarch, Prof. R. H. Walsh.

Date and Place	Presidents	Secretaries
SECTION F (*continued*).—ECONOMIC SCIENCE AND STATISTICS.		
856. Cheltenham	Rt. Hon. Lord Stanley, M.P.	Rev. C. H. Bromby, E. Cheshire, Dr. W. N. Hancock, W. Newmarch, W. M. Tartt.
1857. Dublin......	His Grace the Archbishop of Dublin, M.R.I.A.	Prof. Cairns, Dr. H. D. Hutton, W. Newmarch.
1858. Leeds	Edward Baines	T. B. Baines, Prof. Cairns, S. Brown, Capt. Fishbourne, Dr. J. Strang.
1859. Aberdeen...	Col. Sykes, M.P., F.R.S.	Prof. Cairns, Edmund Macrory, A. M. Smith, Dr. John Strang.
1860. Oxford	Nassau W. Senior, M.A.	Edmund Macrory, W. Newmarch, Rev. Prof. J. E. T. Rogers.
1861. Manchester	William Newmarch, F.R.S....	David Chadwick, Prof. R. C. Christie, E. Macrory, Rev. Prof. J. E. T. Rogers
1862. Cambridge	Edwin Chadwick, C.B.	H. D. Macleod, Edmund Macrory.
1863. Newcastle .	William Tite, M.P., F.R.S. ...	T. Doubleday, Edmund Macrory, Frederick Purdy, James Potts.
1864. Bath	William Farr, M.D., D.C.L., F.R.S.	E. Macrory, E. T. Payne, F. Purdy.
1865. Birmingham	Rt. Hon. Lord Stanley, LL.D., M.P.	G. J. D. Goodman, G. J. Johnston, E. Macrory.
1866. Nottingham	Prof. J. E. T. Rogers............	R. Birkin, jun., Prof. Leone Levi, E. Macrory.
1867. Dundee	M. E. Grant Duff, M.P.	Prof. Leone Levi, E. Macrory, A. J. Warden.
1868. Norwich	Samuel Brown, Pres. Instit. Actuaries.	Rev. W. C. Davie, Prof. Leone Levi.
1869. Exeter	Rt. Hon. Sir Stafford H. Northcote, Bart., C.B., M.P.	E. Macrory, F. Purdy, C. T. D. Acland.
1870. Liverpool...	Prof. W. Stanley Jevons, M.A.	Chas. R. Dudley Baxter, E. Macrory, J. Miles Moss.
1871. Edinburgh	Rt. Hon. Lord Neaves	J. G. Fitch, James Meikle.
1872. Brighton ...	Prof. Henry Fawcett, M.P. ...	J. G. Fitch, Barclay Phillips.
1873. Bradford ...	Rt. Hon. W. E. Forster, M.P.	J. G. Fitch, Swire Smith.
1874. Belfast......	Lord O'Hagan	Prof. Donnell, F. P. Fellows, Hans MacMordie.
1875. Bristol	James Heywood, M.A., F.R.S., Pres.S.S.	F. P. Fellows, T. G. P. Hallett, E. Macrory.
1876. Glasgow ...	Sir George Campbell, K.C.S.I., M.P.	A. M'Neel Caird, T. G. P. Hallett, Dr. W. Neilson Hancock, Dr. W. Jack.
1877. Plymouth...	Rt. Hon. the Earl Fortescue	W. F. Collier, P. Hallett, J. T. Pim.
1878. Dublin	Prof. J. K. Ingram, LL.D., M.R.I.A.	W. J. Hancock, C. Molloy, J. T. Pim.
1879. Sheffield ...	G. Shaw Lefevre, M.P., Pres. S.S.	Prof. Adamson, R. E. Leader, C. Molloy.
1880. Swansea ...	G. W. Hastings, M.P.	N. A. Humphreys, C. Molloy.
1881. York.........	Rt. Hon. M. E. Grant-Duff, M.A., F.R.S.	C. Molloy, W. W. Morrell, J. F. Moss.
1882. Southampton.	Rt. Hon. G. Sclater-Booth, M.P., F.R.S.	G. Baden-Powell, Prof. H. S. Foxwell, A. Milnes, C. Molloy.
1883. Southport	R. H. Inglis Palgrave, F.R.S.	Rev. W. Cunningham, Prof. H. S. Foxwell, J. N. Keynes, C. Molloy.
1884. Montreal ...	Sir Richard Temple, Bart., G.C.S.I., C.I.E., F.R.G.S.	Prof. H. S. Foxwell, J. S. McLennan, Prof. J. Watson.
1885. Aberdeen...	Prof. H. Sidgwick, LL.D., Litt.D.	Rev. W. Cunningham, Prof. H. S. Foxwell, C. McCombie, J. F. Moss.
1886. Birmingham	J. B. Martin, M.A., F.S.S.	F. F. Barham, Rev. W. Cunningham, Prof. H. S. Foxwell, J. F. Moss.

Date and Place	Presidents	Secretaries
1887. Manchester	Robert Giffen, LL.D., V.P.S.S.	Rev. W. Cunningham, F. Y. Edgeworth, T. H. Elliott, C. Hughes, Prof. J. E. C. Munro, G. H. Sargant.
1888. Bath.........	Rt. Hon. Lord Bramwell, LL.D., F.R.S.	Prof. F. Y. Edgeworth, T. H. Elliott, Prof. H. S. Foxwell, L. L. F. R. Price.
1889. Newcastle-upon-Tyne	Prof. F. Y. Edgeworth, M.A., F.S.S.	Rev. Dr. Cunningham, T. H. Elliott, F. B. Jevons, L. L. F. R. Price.

MECHANICAL SCIENCE.

SECTION G.—MECHANICAL SCIENCE.

1836. Bristol	Davies Gilbert, D.C.L., F.R.S.	T. G. Bunt, G. T. Clark, W. West.
1837. Liverpool...	Rev. Dr. Robinson	Charles Vignoles, Thomas Webster.
1838. Newcastle	Charles Babbage, F.R.S.	R. Hawthorn, C. Vignoles, T. Webster.
1839. Birmingham	Prof. Willis, F.R.S., and Robt. Stephenson.	W. Carpmael, William Hawkes, T. Webster.
1840. Glasgow	Sir John Robinson	J. Scott Russell, J. Thomson, J. Tod, C. Vignoles.
1841. Plymouth	John Taylor, F.R.S.	Henry Chatfield, Thomas Webster.
1842. Manchester	Rev. Prof. Willis, F.R.S.	J. F. Bateman, J. Scott Russell, J. Thomson, Charles Vignoles.
1843. Cork	Prof. J. Macneill, M.R.I.A....	James Thomson, Robert Mallet.
1844. York	John Taylor, F.R.S.	Charles Vignoles, Thomas Webster.
1845. Cambridge	George Rennie, F.R.S..........	Rev. W. T. Kingsley.
1846. Southampton.	Rev. Prof. Willis, M.A., F.R.S.	William Betts, jun., Charles Manby.
1847. Oxford	Rev. Prof. Walker, M.A., F.R.S.	J. Glynn, R. A. Le Mesurier.
1848. Swansea ...	Rev. Prof. Walker, M.A., F.R.S.	R. A. Le Mesurier, W. P. Struvé.
1849. Birmingham	Robt. Stephenson, M.P., F.R.S.	Charles Manby, W. P. Marshall.
1850. Edinburgh	Rev. R. Robinson	Dr. Lees, David Stephenson.
1851. Ipswich	William Cubitt, F.R.S..........	John Head, Charles Manby.
1852. Belfast	John Walker, C.E., LL.D., F.R.S.	John F. Bateman, C. B. Hancock, Charles Manby, James Thomson.
1853. Hull	William Fairbairn, C.E., F.R.S.	James Oldham, J. Thomson, W. Sykes Ward.
1854. Liverpool...	John Scott Russell, F.R.S. ...	John Grantham, J. Oldham, J. Thomson.
1855. Glasgow ...	W. J. Macquorn Rankine, C.E., F.R.S.	L. Hill, jun., William Ramsay, J. Thomson.
1856. Cheltenham	George Rennie, F.R.S.	C. Atherton, B. Jones, jun., H. M. Jeffery.
1857. Dublin......	Rt. Hon. the Earl of Rosse, F.R.S.	Prof. Downing, W.T. Doyne, A. Tate, James Thomson, Henry Wright.
1858. Leeds	William Fairbairn, F.R.S. ...	J. C. Dennis, J. Dixon, H. Wright.
1859. Aberdeen...	Rev. Prof. Willis, M.A., F.R.S.	R. Abernethy, P. Le Neve Foster, H. Wright.
1860. Oxford	Prof. W. J. Macquorn Rankine, LL.D., F.R.S.	P. Le Neve Foster, Rev. F. Harrison, Henry Wright.
1861. Manchester	J. F. Bateman, C.E., F.R.S....	P. Le Neve Foster, John Robinson, H. Wright.
1862. Cambridge	Wm. Fairbairn, LL.D., F.R.S.	W. M. Fawcett, P. Le Neve Foster.
1863. Newcastle	Rev. Prof. Willis, M.A., F.R.S.	P. Le Neve Foster, P. Westmacott, J. F. Spencer.
1864. Bath	J. Hawkshaw, F.R.S.	P. Le Neve Foster, Robert Pitt.

Date and Place	Presidents	Secretaries
1865. Birmingham	Sir W. G. Armstrong, LL.D., F.R.S.	P. Le Neve Foster, Henry Lea, W. P. Marshall, Walter May.
1866. Nottingham	Thomas Hawksley, V.P.Inst. C.E., F.G.S.	P. Le Neve Foster, J. F. Iselin, M. O. Tarbotton.
1867. Dundee......	Prof. W. J. Macquorn Rankine, LL.D., F.R.S.	P. Le Neve Foster, John P. Smith, W. W. Urquhart.
1868. Norwich ...	G. P. Bidder, C.E., F.R.G.S.	P. Le Neve Foster, J. F. Iselin, C. Manby, W. Smith.
1869. Exeter	C. W. Siemens, F.R.S..........	P. Le Neve Foster, H. Bauerman.
1870. Liverpool...	Chas. B. Vignoles, C.E., F.R.S.	H. Bauerman, P. Le Neve Foster, T. King, J. N. Shoolbred.
1871. Edinburgh	Prof. Fleeming Jenkin, F.R.S.	H. Bauerman, Alexander Leslie, J. P. Smith.
1872. Brighton ...	F. J. Bramwell, C.E.	H. M. Brunel, P. Le Neve Foster, J. G. Gamble, J. N. Shoolbred.
1873. Bradford ...	W. H. Barlow, F.R.S.	Crawford Barlow, H. Bauerman, E. H. Carbutt, J. C. Hawkshaw, J. N. Shoolbred.
1874. Belfast	Prof. James Thomson, LL.D., C.E., F.R.S.E.	A. T. Atchison, J. N. Shoolbred, John Smyth, jun.
1875. Bristol	W. Froude, C.E., M.A., F.R.S.	W. R. Browne, H. M. Brunel, J. G. Gamble, J. N. Shoolbred.
1876. Glasgow ...	C. W. Merrifield, F.R.S.	W. Bottomley, jun., W. J. Millar, J. N. Shoolbred, J. P. Smith.
1877. Plymouth...	Edward Woods, C.E.	A. T. Atchison, Dr. Merrifield, J. N. Shoolbred.
1878. Dublin	Edward Easton, C.E.	A. T. Atchison, R. G. Symes, H. T. Wood.
1879. Sheffield ...	J. Robinson, Pres. Inst. Mech. Eng.	A. T. Atchison, Emerson Bainbridge, H. T. Wood.
1880. Swansea ...	James Abernethy, V.P. Inst. C.E., F.R.S.E.	A. T. Atchison, H. T. Wood.
1881. York.........	Sir W. G. Armstrong, C.B., LL.D., D.C.L., F.R.S.	A. T. Atchison, J. F. Stephenson, H. T. Wood.
1882. Southampton.	John Fowler, C.E., F.G.S. ...	A. T. Atchison, F. Churton, H. T. Wood.
1883. Southport	James Brunlees, F.R.S.E., Pres.Inst.C.E.	A. T. Atchison, E. Rigg, H. T. Wood.
1884. Montreal ...	Sir F. J. Bramwell, F.R.S., V.P.Inst.C.E.	A. T. Atchison, W. B. Dawson, J. Kennedy, H. T. Wood.
1885. Aberdeen...	B. Baker, M.Inst.C.E.	A. T. Atchison, F. G. Ogilvie, E. Rigg, J. N. Shoolbred.
1886. Birmingham	Sir J. N. Douglass, M.Inst. C.E.	C. W. Cooke, J. Kenward, W. B. Marshall, E. Rigg.
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1889. Newcastle-upon-Tyne	W. Anderson, M.Inst.C.E. ...	C. W. Cooke, W. B. Marshall, Hon. C. A. Parsons, E. Rigg.

ANTHROPOLOGICAL SCIENCE.

SECTION H.—ANTHROPOLOGY.

1884. Montreal ...	E. B. Tylor, D.C.L., F.R.S. ...	G. W. Bloxam, W. Hurst.
1885. Aberdeen...	Francis Galton, M.A., F.R.S.	G. W. Bloxam, Dr. J. G. Garson, W. Hurst, Dr. A. Macgregor.

Date and Place	Presidents	Secretaries
1886. Birmingham	Sir G. Campbell, K.C.S.I., M.P., D.C.L., F.R.G.S.	G. W. Bloxam, Dr. J. G. Garson, W. Hurst, Dr. R. Saundby
1887. Manchester	Prof. A. H. Sayce, M.A.	G. W. Bloxam, Dr. J. G. Garson, Dr. A. M. Paterson.
1888. Bath.........	Lieut.-General Pitt-Rivers, D.C.L., F.R S.	G. W. Bloxam, Dr. J. G. Garson, J. Harris Stone.
1889. Newcastle-upon-Tyne	Prof. Sir W. Turner, M.B., LL.D., F.R.S.	G. W. Bloxam, Dr. J. G. Garson, Dr. R. Morison, Dr. R. Howden.

LIST OF EVENING LECTURES.

Date and Place	Lecturer	Subject of Discourse
1842. Manchester	Charles Vignoles, F.R.S......	The Principles and Construction of Atmospheric Railways.
	Sir M. I. Brunel	The Thames Tunnel.
	R. I. Murchison..................	The Geology of Russia.
1843. Cork	Prof. Owen, M.D., F.R.S.......	The Dinornis of New Zealand.
	Prof. E. Forbes, F.R.S..........	The Distribution of Animal Life in the Ægean Sea.
	Dr. Robinson	The Earl of Rosse's Telescope.
1844. York	Charles Lyell, F.R.S.	Geology of North America.
	Dr. Falconer, F.R.S.............	The Gigantic Tortoise of the Siwalik Hills in India.
1845. Cambridge	G.B.Airy,F.R.S.,Astron.Royal	Progress of Terrestrial Magnetism.
	R. I. Murchison, F.R.S.	Geology of Russia.
1846. Southampton.	Prof. Owen, M.D., F.R.S. ...	Fossil Mammalia of the British Isles.
	Charles Lyell, F.R.S.	Valley and Delta of the Mississippi.
	W. R. Grove, F.R.S.	Properties of the Explosive substance discovered by Dr. Schönbein; also some Researches of his own on the Decomposition of Water by Heat.
1847. Oxford......	Rev. Prof. B. Powell, F.R.S.	Shooting Stars.
	Prof. M. Faraday, F.R.S.......	Magnetic and Diamagnetic Phenomena.
	Hugh E. Strickland, F.G.S....	The Dodo (*Didus ineptus*).
1848. Swansea ...	John Percy, M.D., F.R.S.......	Metallurgical Operations of Swansea and its neighbourhood.
	W. Carpenter, M.D., F.R.S....	Recent Microscopical Discoveries.
1849. Birmingham	Dr. Faraday, F.R.S.	Mr. Gassiot's Battery.
	Rev. Prof. Willis, M.A., F.R.S.	Transit of different Weights with varying velocities on Railways.
1850. Edinburgh	Prof. J. H. Bennett, M.D., F.R.S.E.	Passage of the Blood through the minute vessels of Animals in connection with Nutrition.
	Dr. Mantell, F.R.S.	Extinct Birds of New Zealand.
1851. Ipswich ...	Prof. R. Owen, M.D., F.R.S.	Distinction between Plants and Animals, and their changes of Form.
	G.B.Airy,F.R.S.,Astron. Royal	Total Solar Eclipse of July 28, 1851.
1852. Belfast......	Prof. G. G. Stokes, D.C.L., F.R.S.	Recent discoveries in the properties of Light.
	Colonel Portlock, R.E., F.R.S.	Recent discovery of Rock-salt at Carrickfergus, and geological and practical considerations connected with it.

Date and Place	Lecturer	Subject of Discourse
1853. Hull	Prof. J. Phillips, LL.D., F.R.S., F.G.S.	Some peculiar Phenomena in the Geology and Physical Geography of Yorkshire.
	Robert Hunt, F.R.S.	The present state of Photography.
1854. Liverpool...	Prof. R. Owen, M.D., F.R.S.	Anthropomorphous Apes.
	Col. E. Sabine, V.P.R.S.	Progress of researches in Terrestrial Magnetism.
1855. Glasgow ...	Dr. W. B. Carpenter, F.R.S.	Characters of Species.
	Lieut.-Col. H. Rawlinson ...	Assyrian and Babylonian Antiquities and Ethnology.
1856. Cheltenham	Col. Sir H. Rawlinson	Recent Discoveries in Assyria and Babylonia, with the results of Cuneiform research up to the present time.
	W. R. Grove, F.R.S.	Correlation of Physical Forces.
1857. Dublin......	Prof. W. Thomson, F.R.S. ...	The Atlantic Telegraph.
	Rev. Dr. Livingstone, D.C.L.	Recent Discoveries in Africa.
1858. Leeds	Prof. J. Phillips, LL.D., F.R.S.	The Ironstones of Yorkshire.
	Prof. R. Owen, M.D., F.R.S.	The Fossil Mammalia of Australia.
1859. Aberdeen...	Sir R. I. Murchison, D.C.L....	Geology of the Northern Highlands.
	Rev. Dr. Robinson, F.R.S. ...	Electrical Discharges in highly rarefied Media.
1860. Oxford......	Rev. Prof. Walker, F.R.S. ...	Physical Constitution of the Sun.
	Captain Sherard Osborn, R.N.	Arctic Discovery.
1861. Manchester	Prof. W. A. Miller, M.A., F.R.S.	Spectrum Analysis.
	G. B. Airy, F.R.S., Astron. Royal	The late Eclipse of the Sun.
1862. Cambridge	Prof. Tyndall, LL.D., F.R.S.	The Forms and Action of Water.
	Prof. Odling, F.R.S.	Organic Chemistry.
1863. Newcastle	Prof. Williamson, F.R.S.......	The Chemistry of the Galvanic Battery considered in relation to Dynamics.
	James Glaisher, F.R.S.........	The Balloon Ascents made for the British Association.
1864. Bath.........	Prof. Roscoe, F.R.S.	The Chemical Action of Light.
	Dr. Livingstone, F.R.S.	Recent Travels in Africa.
1865. Birmingham	J. Beete Jukes, F.R.S..........	Probabilities as to the position and extent of the Coal-measures beneath the red rocks of the Midland Counties.
1866. Nottingham	William Huggins, F.R.S. ...	The results of Spectrum Analysis applied to Heavenly Bodies.
	Dr. J. D. Hooker, F.R.S.......	Insular Floras.
1867. Dundee......	Archibald Geikie, F.R.S.......	The Geological Origin of the present Scenery of Scotland.
	Alexander Herschel, F.R.A.S.	The present state of knowledge regarding Meteors and Meteorites.
1868. Norwich ...	J. Fergusson, F.R.S.............	Archæology of the early Buddhist Monuments.
	Dr. W. Odling, F.R.S.	Reverse Chemical Actions.
1869. Exeter	Prof. J. Phillips, LL.D., F.R.S.	Vesuvius.
	J. Norman Lockyer F.R.S. ..	The Physical Constitution of the Stars and Nebulæ.
1870. Liverpool...	Prof. J. Tyndall, LL.D., F.R.S.	Scientific Use of the Imagination.
	Prof. W. J. Macquorn Rankine, LL.D., F.R.S.	Stream-lines and Waves, in connection with Naval Architecture.
1871. Edinburgh	F. A. Abel, F.R.S.......	Some recent investigations and applications of Explosive Agents.
	E. B. Tylor, F.R.S.	The Relation of Primitive to Modern Civilization.

Date and Place	Lecturer	Subject of Discourse
1872. Brighton ...	Prof. P. Martin Duncan, M.B., F.R.S.	Insect Metamorphosis.
	Prof. W. K. Clifford	The Aims and Instruments of Scientific Thought.
1873. Bradford ...	Prof. W. C. Williamson, F.R.S.	Coal and Coal Plants.
	Prof. Clerk Maxwell, F.R.S.	Molecules.
1874. Belfast	Sir John Lubbock, Bart., M.P., F.R.S.	Common Wild Flowers considered in relation to Insects.
	Prof. Huxley, F.R.S.	The Hypothesis that Animals are Automata, and its History.
1875. Bristol	W. Spottiswoode, LL.D., F.R.S.	The Colours of Polarized Light.
	F. J. Bramwell, F.R.S..........	Railway Safety Appliances.
1876. Glasgow ...	Prof. Tait, F.R.S.E.	Force.
	Sir Wyville Thomson, F.R.S.	The *Challenger* Expedition.
1877. Plymouth...	W. Warington Smyth, M.A., F.R.S.	The Physical Phenomena connected with the Mines of Cornwall and Devon.
	Prof. Odling, F.R.S.............	The new Element, Gallium.
1878. Dublin	G. J. Romanes, F.L.S.	Animal Intelligence.
	Prof. Dewar, F.R.S.	Dissociation, or Modern Ideas of Chemical Action.
1879. Sheffield ...	W. Crookes, F.R.S.	Radiant Matter.
	Prof. E. Ray Lankester, F.R.S.	Degeneration.
1880. Swansea ...	Prof. W. Boyd Dawkins, F.R.S.	Primeval Man.
	Francis Galton, F.R.S..........	Mental Imagery.
1881. York.........	Prof. Huxley, Sec. R.S.	The Rise and Progress of Palæontology.
	W. Spottiswoode, Pres. R.S.	The Electric Discharge, its Forms and its Functions.
1882. Southampton.	Prof. Sir Wm. Thomson, F.R.S.	Tides.
	Prof. H. N. Moseley, F.R.S.	Pelagic Life.
1883. Southport	Prof. R. S. Ball, F.R.S.	Recent Researches on the Distance of the Sun.
	Prof. J. G. McKendrick, F.R.S.E.	Galvani and Animal Electricity.
1884. Montreal ...	Prof. O. J. Lodge, D.Sc.	Dust.
	Rev. W. H. Dallinger, F.R.S.	The Modern Microscope in Researches on the Least and Lowest Forms of Life.
1885. Aberdeen...	Prof. W. G. Adams, F.R.S. ...	The Electric Light and Atmospheric Absorption.
	John Murray, F.R.S.E..........	The Great Ocean Basins.
1886. Birmingham	A. W. Rücker, M.A., F.R.S.	Soap Bubbles.
	Prof. W. Rutherford, M.D. ...	The Sense of Hearing.
1887. Manchester	Prof. H. B. Dixon, F.R.S. ...	The Rate of Explosions in Gases.
	Col. Sir F. de Winton, K.C.M.G.	Explorations in Central Africa.
1888. Bath.........	Prof. W. E. Ayrton, F.R.S. ...	The Electrical Transmission of Power.
	Prof. T. G. Bonney, D.Sc., F.R.S.	The Foundation Stones of the Earth's Crust.
1889. Newcastle-upon-Tyne	Prof. W. C. Roberts-Austen, F.R.S.	The Hardening and Tempering of Steel.
	Walter Gardiner, M.A.........	How Plants maintain themselves in the Struggle for Existence.

LECTURES TO THE OPERATIVE CLASSES.

Date and Place	Lecturer	Subject of Discourse
1867. Dundee......	Prof. J. Tyndall, LL.D., F.R.S.	Matter and Force.
1868. Norwich ...	Prof. Huxley, LL.D., F.R.S.	A Piece of Chalk.
1869. Exeter	Prof. Miller, M.D., F.R.S. ...	Experimental illustrations of the modes of detecting the Composition of the Sun and other Heavenly Bodies by the Spectrum.
1870. Liverpool .	Sir John Lubbock, Bart., M.P., F.R.S.	Savages.
1872. Brighton ...	W. Spottiswoode, LL.D., F.R.S.	Sunshine, Sea, and Sky.
1873. Bradford ...	C. W. Siemens, D.C.L., F.R.S.	Fuel.
1874. Belfast	Prof. Odling, F.R.S.	The Discovery of Oxygen.
1875. Bristol	Dr. W. B. Carpenter, F.R.S.	A Piece of Limestone.
1876. Glasgow ...	Commander Cameron, C.B., R.N.	A Journey through Africa.
1877. Plymouth...	W. H. Preece	Telegraphy and the Telephone.
1879. Sheffield ...	W. E. Ayrton	Electricity as a Motive Power.
1880. Swansea ...	H. Seebohm, F.Z.S.	The North-East Passage.
1881. York	Prof. Osborne Reynolds, F.R.S.	Raindrops, Hailstones, and Snowflakes.
1882. Southampton.	John Evans, D.C.L., Treas. R.S.	Unwritten History, and how to read it.
1883. Southport	Sir F. J. Bramwell, F.R.S. ...	Talking by Electricity—Telephones.
1884. Montreal ...	Prof. R. S. Ball, F.R.S.	Comets.
1885. Aberdeen ...	H. B. Dixon, M.A.	The Nature of Explosions.
1886. Birmingham	Prof. W. C. Roberts-Austen, F.R.S.	The Colours of Metals and their Alloys.
1887. Manchester	Prof. G. Forbes, F.R.S.	Electric Lighting.
1888. Bath	Sir John Lubbock, Bart., M.P., F.R.S.	The Customs of Savage Races.
1889. Newcastle-upon-Tyne	B. Baker, M.Inst.C.E.	The Forth Bridge.

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„ Associates' Tickets at Bath Meeting	621	0	0
„ Ladies' Tickets at Bath Meeting	509	0	0
„ Sale of Publications	47	18	6
„ Sale of Reports, by Mr. Murray, 1887–1888	108	0	0
„ Sale of Reports, by Mr. Murray, 1888–1889	108	16	0
„ Rent received from Mathematical Society, for year ended September 29, 1888	12	15	0
„ Interest on Exchequer Bills	10	19	5
„ Dividends on Consols	243	9	1
„ Dividends on India 3 per cents.	105	6	0
„ Return of grants paid to Mr. S. Bourne for 'Precious Metals in use' and 'Monetary Standards'	30	0	0
„ Unexpended balance of Grant for Ceylon Botanical Station	7	6	5
„ Unexpended balance of Grant for 'Nomenclature for Fundamental Units of Mechanics'	7	2	5
	£3451	3	3

Investments Account: September, 1888, *to September*, 1889.

DEBIT.

	£	s.	d.
New Consols	8500	0	0
India 3 per cents.	3600	0	0
Exchequer Bills	500	0	0
Cash	239	10	5
Excess of Receipts over Expenditure	812	14	7
Total	£13,652	5	0

CREDIT.

	£	s.	d.
New Consols	8500	0	0
India 3 per cents.	3600	0	0
Exchequer Bills	500	0	0
Cash	1052	5	0
Total	£13,652	5	0

THE ADVANCEMENT OF SCIENCE.

(not including receipts at the Newcastle Meeting). *Cr.*

1888–89. PAYMENTS.

	£	s.	d.
To Expenses of Bath Meeting, including Printing, Advertising, &c., also Expenses of Lecture by Professor Ayrton	339	17	4
,, Salaries, one year (1888–89)	525	0	0
,, Rent of Office at Albemarle Street (1888–89)	117	0	0

GRANTS.

	£	s.	d.	£	s.	d.
Volcanic Phenomena of Japan	25	0	0			
Geology and Geography of Atlas Range	100	0	0			
Observations on Surface Water Temperature	30	0	0			
Bath 'Baths Committee' for further Researches	100	0	0			
Flora of China	25	0	0			
Natural History of Friendly Islands	100	0	0			
Physiology of Lymphatic System	25	0	0			
Volcanic Phenomena of Vesuvius	20	0	0			
Charateristics of Nomad Tribes of Asia Minor	30	0	0			
Fossil Phyllopoda of Palæozoic Rocks	20	0	0			
Investigation into North-Western Tribes of Canada	150	0	0			
West Indian Explorations	100	0	0			
Corresponding Societies	20	0	0			
Experiments with a Tow Net	5	16	3			
Geological Record	80	0	0			
Marine Biological Association	200	0	0			
Naples Zoological Station	100	0	0			
Higher Eocene Beds of Isle of Wight	15	0	0			
Ben Nevis Observatory	50	0	0			
Methods of Teaching Chemistry	10	0	0			
Action of Light on Hydracids of the Halogen in presence of Oxygen	10	0	0			
Electrical Standards	75	0	0			
Action of Waves and Currents in Estuaries by means of Working Models	100	0	0			
Electrolysis	20	0	0			
Silent Discharge of Electricity on Oxygen	6	4	8			
				1417	0	11
By Balance at Bank of England, Western Branch				1052	5	0
				£3451	3	3

ALEX. W. WILLIAMSON, *Treasurer.*

Table showing the Attendance and Receipt

Date of Meeting	Where held	Presidents	Old Life Members	New Life Members
1831, Sept. 27 ...	York	The Earl Fitzwilliam, D.C.L.	...	...
1832, June 19 ...	Oxford	The Rev. W. Buckland, F.R.S.	...	...
1833, June 25 ...	Cambridge	The Rev. A. Sedgwick, F.R.S.	...	...
1834, Sept. 8 ...	Edinburgh	Sir T. M. Brisbane, D.C.L.......	...	...
1835, Aug. 10 ...	Dublin	The Rev. Provost Lloyd, LL.D.	...	...
1836, Aug. 22 ...	Bristol	The Marquis of Lansdowne ...	...	...
1837, Sept. 11 ...	Liverpool	The Earl of Burlington, F.R.S.	...	...
1838, Aug. 10 ...	Newcastle-on-Tyne	The Duke of Northumberland	...	...
1839, Aug. 26 ...	Birmingham.........	The Rev. W. Vernon Harcourt	...	...
1840, Sept. 17 ...	Glasgow	The Marquis of Breadalbane...	...	...
1841, July 20 ...	Plymouth	The Rev. W. Whewell, F.R.S.	169	65
1842, June 23 ...	Manchester	The Lord Francis Egerton......	303	169
1843, Aug. 17 ...	Cork	The Earl of Rosse, F.R.S.	109	28
1844, Sept. 26 ...	York	The Rev. G. Peacock, D.D. ...	226	150
1845, June 19 ...	Cambridge	Sir John F. W. Herschel, Bart.	313	36
1846, Sept. 10 ...	Southampton	Sir Roderick I. Murchison, Bart.	241	10
1847, June 23 ...	Oxford	Sir Robert H. Inglis, Bart.......	314	18
1848, Aug. 9 ...	Swansea	The Marquis of Northampton	149	3
1849, Sept. 12 ...	Birmingham.........	The Rev. T. R. Robinson, D.D.	227	12
1850, July 21 ...	Edinburgh	Sir David Brewster, K.H.	235	9
1851, July 2 ...	Ipswich	G. B. Airy, Astronomer Royal	172	8
1852, Sept. 1 ...	Belfast	Lieut.-General Sabine, F.R.S.	164	10
1853, Sept. 3 ...	Hull	William Hopkins, F.R.S.	141	13
1854, Sept. 20 ...	Liverpool	The Earl of Harrowby, F.R.S.	238	23
1855, Sept. 12 ...	Glasgow	The Duke of Argyll, F.R.S. ...	194	33
1856, Aug. 6 ...	Cheltenham	Prof. C. G. B. Daubeny, M.D.	182	14
1857, Aug. 26 ...	Dublin	The Rev. Humphrey Lloyd, D.D.	236	15
1858, Sept. 22 ...	Leeds..................	Richard Owen, M.D., D.C.L....	222	42
1859, Sept. 14 ...	Aberdeen	H.R.H. the Prince Consort ...	184	27
1860, June 27 ...	Oxford	The Lord Wrottesley, M.A. ...	286	21
1861, Sept. 4 ...	Manchester	William Fairbairn, LL.D., F.R.S.	321	113
1862, Oct. 1 ...	Cambridge	The Rev. Professor Willis, M.A.	239	15
1863, Aug. 26 ...	Newcastle-on-Tyne	Sir William G. Armstrong, C.B.	203	36
1864, Sept. 13 ...	Bath	Sir Charles Lyell, Bart., M.A.	287	40
1865, Sept. 6 ...	Birmingham.........	Prof. J. Phillips, M.A., LL.D.	292	44
1866, Aug. 22 ...	Nottingham	William R. Grove, Q.C., F.R.S.	207	31
1867, Sept. 4 ...	Dundee	The Duke of Buccleuch, K.C.B.	167	25
1868, Aug. 19 ...	Norwich	Dr. Joseph D. Hooker, F.R.S.	196	18
1869, Aug. 18 ...	Exeter	Prof. G. G. Stokes, D.C.L.......	204	21
1870, Sept. 14 ...	Liverpool	Prof. T. H. Huxley, LL.D.......	314	39
1871, Aug. 2 ...	Edinburgh	Prof. Sir W. Thomson, LL.D.	246	28
1872, Aug. 14 ...	Brighton	Dr. W. B. Carpenter, F.R.S. ...	245	36
1873, Sept. 17 ...	Bradford	Prof. A. W. Williamson, F.R.S.	212	27
1874, Aug. 19 ...	Belfast	Prof. J. Tyndall, LL.D., F.R.S.	162	13
1875, Aug. 25 ...	Bristol	Sir John Hawkshaw, C.E., F.R.S.	239	36
1876, Sept. 6 ...	Glasgow	Prof. T. Andrews, M.D., F.R.S.	221	35
1877, Aug. 15 ...	Plymouth	Prof. A. Thomson, M.D., F.R.S.	173	19
1878, Aug. 14 ...	Dublin	W. Spottiswoode, M.A., F.R.S.	201	18
1879, Aug. 20 ...	Sheffield	Prof. G. J. Allman, M.D., F.R.S.	184	16
1880, Aug. 25 ...	Swansea	A. C. Ramsay, LL.D., F.R.S....	144	11
1881, Aug. 31 ...	York	Sir John Lubbock, Bart., F.R.S.	272	28
1882, Aug. 23 ...	Southampton	Dr. C. W. Siemens, F.R.S.......	178	17
1883, Sept. 19 ...	Southport	Prof. A. Cayley, D.C.L., F.R.S.	203	60
1884, Aug. 27 ...	Montreal	Prof. Lord Rayleigh, F.R.S. ...	235	20
1885, Sept. 9 ...	Aberdeen	Sir Lyon Playfair, K.C.B., F.R.S.	225	18
1886, Sept. 1 ...	Birmingham.........	Sir J.W. Dawson, C.M.G., F.R.S.	314	25
1887, Aug. 31 ...	Manchester	Sir H. E. Roscoe, D.C.L., F.R.S.	428	86
1888, Sept. 5 ...	Bath	Sir F. J. Bramwell, F.R.S.......	266	36
1889, Sept. 11 ...	Newcastle-on-Tyne	Prof. W. H. Flower, C.B., F.R.S.	277	20

* Ladies were not admitted by purchased Tickets until 1843. † Tickets of Admission to Sections on

...t Annual Meetings of the Association.

Attended by						Amount received during the Meeting	Sums paid on Account of Grants for Scientific Purposes	Year
Old Annual Members	New Annual Members	Associates	Ladies	Foreigners	Total			
...	...	...	...	...	353	....	....	1831
...	...	...	...	...	...	....	....	1832
...	...	...	...	...	900	....	....	1833
...	...	...	...	...	1298	....	£20 0 0	1834
...	...	...	...	...	...	....	167 0 0	1835
...	...	...	...	...	1350	....	435 0 0	1836
...	...	...	...	...	1840	....	922 12 6	1837
...	...	...	1100*	...	2400	....	932 2 2	1838
...	...	...	...	34	1438	....	1595 11 0	1839
...	...	...	...	40	1353	....	1546 16 4	1840
46	317	...	60*	...	891	....	1235 10 11	1841
75	376	33†	331*	28	1315	....	1449 17 8	1842
71	185	...	160	...	...	....	1565 10 2	1843
45	190	9†	260	...	...	....	981 12 8	1844
94	22	407	172	35	1079	....	831 9 9	1845
65	39	270	196	36	857	....	685 16 0	1846
197	40	495	203	53	1320	....	208 5 4	1847
54	25	376	197	15	819	£707 0 0	275 1 8	1848
93	33	447	237	22	1071	963 0 0	159 19 6	1849
128	42	510	273	44	1241	1085 0 0	345 18 0	1850
61	47	244	141	37	710	620 0 0	391 9 7	1851
63	60	510	292	9	1108	1085 0 0	304 6 7	1852
56	57	367	236	6	876	903 0 0	205 0 0	1853
121	121	765	524	10	1802	1882 0 0	380 19 7	1854
142	101	1094	543	26	2133	2311 0 0	480 16 4	1855
104	48	412	346	9	1115	1098 0 0	734 13 9	1856
156	120	900	569	26	2022	2015 0 0	507 15 4	1857
111	91	710	509	13	1698	1931 0 0	618 18 2	1858
125	179	1206	821	22	2564	2782 0 0	684 11 1	1859
177	59	636	463	47	1689	1604 0 0	766 19 6	1860
184	125	1589	791	15	3138	3944 0 0	1111 5 10	1861
150	57	433	242	25	1161	1089 0 0	1293 16 6	1862
154	209	1704	1004	25	3335	3640 0 0	1608 3 10	1863
182	103	1119	1058	13	2802	2965 0 0	1289 15 8	1864
215	149	766	508	23	1997	2227 0 0	1591 7 10	1865
218	105	960	771	11	2303	2469 0 0	1750 13 4	1866
193	118	1163	771	7	2444	2613 0 0	1739 4 0	1867
226	117	720	682	45‡	2004	2042 0 0	1940 0 0	1868
229	107	678	600	17	1856	1931 0 0	1622 0 0	1869
303	195	1103	910	14	2878	3096 0 0	1572 0 0	1870
311	127	976	754	21	2463	2575 0 0	1472 2 6	1871
280	80	937	912	43	2533	2649 0 0	1285 0 0	1872
237	99	796	601	11	1983	2120 0 0	1685 0 0	1873
232	85	817	630	12	1951	1979 0 0	1151 16 0	1874
307	93	884	672	17	2248	2397 0 0	960 0 0	1875
331	185	1265	712	25	2774	3023 0 0	1092 4 2	1876
238	59	446	283	11	1229	1268 0 0	1128 9 7	1877
290	93	1285	674	17	2578	2615 0 0	725 16 6	1878
239	74	529	349	13	1404	1425 0 0	1080 11 11	1879
171	41	389	147	12	915	899 0 0	731 7 7	1880
313	176	1230	514	24	2557	2689 0 0	476 3 1	1881
253	79	516	189	21	1253	1286 0 0	1126 1 11	1882
330	323	952	841	5	2714	3369 0 0	1083 3 3	1883
317	219	826	74	26 & 60 H.§	1777	1538 0 0	1173 4 0	1884
332	122	1053	447	6	2203	2256 0 0	1385 0 0	1885
428	179	1067	29	11	2453	2532 0 0	995 0 6	1886
510	244	1985	493	92	3838	4336 0 0	1186 18 0	1887
399	100	639	509	35	1984	2107 0 0	1511 0 5	1888
412	113	1024	579	12	2437	2441 0 0	1417 0 11	1889

Including Ladies. § Fellows of the American Association were admitted as Hon. Members for this Meeting

REPORT OF THE COUNCIL.

Report of the Council for the year 1888–89, *presented to the General Committee at Newcastle-upon-Tyne, on Wednesday, September* 11, 1889.

The Council have received reports during the past year from the General Treasurer, and his account for the year will be laid before the General Committee this day.

Since the Meeting at Bath the following have been elected Corresponding Members of the Association:—

W. H. Dall, U.S. Geological Survey.
G. K. Gilbert, U.S. Geological Survey.
Dr. Max von Hantken, Budapest.
Horatio Hale, Ontario.
Prof. G. Stefanescu, Bucharest.
Wladimir Vernadsky, University of St. Petersburg.

The Council have nominated Sir Charles Mark Palmer, Bart, M.P., a Vice-President of the meeting at Newcastle-upon-Tyne.

An invitation for the year 1891 will be presented from Cardiff.

The General Committee having granted a sum of 200*l.* at their last meeting to the Marine Biological Association, thus making up the total sum given by the Association to 500*l.*, the Association became entitled to nominate a Governor of the Marine Biological Association, and the Council have nominated Professor Flower to the office.

It having been reported that the Committee on the Prehistoric Inhabitants of the British Islands, appointed on the recommendation of the Committee of Section H, had, through an oversight of the Sectional Secretary, not been reappointed, the Committee have been informed that if they will make a report to the Section, as if duly appointed, the Council are prepared to bring the matter before the Committee of Recommendations, with a view to the appointment of the Committee, and the publication of their Report.

A request having been received from the Honorary Secretaries of the International Congress of Hygiene and Statistics, that the Association would nominate two members to serve on the General Committee to be formed for organising the Congress, the Council have nominated Sir Frederick J. Bramwell and Sir H. E. Roscoe for that purpose.

The following resolution was referred by the General Committee to the Council for consideration and action if desirable:—

'That the Council be recommended to consider what measures, if any, it might be desirable to take with respect to the apparatus from time to time purchased by funds voted by the Association.'

The Council, after consideration of the question, are of opinion that the attention of the Chairmen and Members of Committees should be specially directed to the existing rules, viz.:—

'Members and Committees who may be entrusted with sums of money for collecting specimens of Natural History are requested to reserve the specimens so obtained for distribution by authority of the Association.

All instruments, papers, drawings, and other property of the Association, are to be deposited in the office, 22 Albemarle Street, London, when not employed in carrying on scientific inquiries for the Association,'

and that they should be requested in each year, prior to the dissolution of the Committee, to furnish a list of any apparatus which may have been purchased out of the grant made by the Association, distinguishing the apparatus which in their opinion may continue to be useful for the research in question or for other scientific purposes.

The following resolution was referred by the General Committee to the Council for consideration and action if desirable :—

'That the Council of the Association be requested to urge upon the Corporation of Bath the desirability of laying bare a further portion of the unique Roman Baths at that city, with a view to their permanent preservation; and that the part already laid bare should be protected from the weather.'

The Council resolved that the views set forth in the resolution should be embodied in a letter and forwarded to the Corporation of Bath, together with a cheque for the sum of 100*l*., which the General Committee had resolved to place at the disposal of the Baths Committee of the Bath Corporation for the prosecution of their investigations.

The following resolution was referred by the General Committee to the Council for consideration and action if desirable :—

'That the Council be requested to memorialise her Majesty's Government in favour of establishing a permanent census sub-department, and taking the census of the United Kingdom every five years.'

The Council are of opinion that it is inexpedient to take action in the matter.

A request was made on behalf of the Committee of Section H that the Council would communicate to the Canadian Government the fact that the Association had granted 150*l*. to a committee for investigating the North-Western Tribes of the Dominion, and would express the desirability of this grant being supplemented to an equal amount by the Canadian Government. A letter was written to the Canadian Government in accordance with the above request, asking them to contribute a similar amount to that granted by the Association, and a letter from the Secretary of the High Commissioner for Canada was subsequently received transmitting a copy of an Order in Council recommending that the application should be granted.

Early in the present year Mr. Atchison, the Secretary, informed the Council that his health had materially suffered during the past winter; that his medical advisers stated that it was imperative for him to spend the next three winters in a warm climate; and that, under those circumstances, he did not propose to offer himself for re-election at the next meeting of the Association. The Council received this announcement with great regret; but as there appeared to be no prospect of Mr. Atchison being able to avoid this absence from England, they took into consideration the duties of the office which he had held and the appointment of a successor.

The Council resolved that it is desirable that the officer to be appointed in Mr. Atchison's place, to act under the direction of the General Secretaries, should be named, as formerly, Assistant General Secretary, that the salary should be fixed at 300*l*. a year, and that the expense of journeys undertaken on behalf of the Association should be repaid.

The Council have nominated Mr. Hubert Llewellyn Smith for the appointment.

The report of the Corresponding Societies Committee is herewith submitted to the General Committee.

The Corresponding Societies Committee, consisting of Mr. Francis Galton (Chairman), Professor R. Meldola (Secretary), Professor A. W. Williamson, Sir Douglas Galton, Professor Boyd Dawkins, Sir Rawson Rawson, Dr. J. G. Garson, Dr. J. Evans, Mr. J. Hopkinson, Mr. W. Whitaker, Mr. G. J. Symons, General Pitt-Rivers, Mr. W. Topley, and Professor T. G. Bonney, is hereby nominated for reappointment by the General Committee.

The Council nominate Mr. Francis Galton, F.R.S., Chairman, Professor T. G. Bonney, F.R.S., Vice-Chairman, and Professor G. A. Lebour, F.G.S., Secretary to the Conference of Delegates of Corresponding Societies to be held during the Newcastle-upon-Tyne meeting.

In accordance with the regulations the five retiring Members of the Council will be:—

Capt. W. de W. Abney.
W. H. Barlow, Esq.
Lieut.-Col. H. H. Godwin-Austen.
Prof. O. Henrici.
W. T. Thiselton-Dyer, Esq.

The Council recommend the re-election of the other ordinary Members of Council, with the addition of the gentlemen whose names are distinguished by an asterisk in the following list:—

*Ayrton, Prof. W. E., F.R.S.
*Baker, B., Esq., M.Inst.C.E.
Ball, Sir R. S., F.R.S.
Blanford, W. T., Esq., F.R.S.
Crookes, W., Esq., F.R.S.
Darwin, Prof. G. H., F.R.S.
Douglass, Sir James, F.R.S.
*Evans, Dr. J., F.R.S.
*Fitzgerald, Prof. G. F., F.R.S.
Gamgee, Dr. A., F.R.S.
Geikie, Dr. A., F.R.S.
Judd, Prof. J. W., F.R.S.
*Lankester, Prof. E. Ray, F.R.S.
Liveing, Prof. G.D., F.R.S.
Martin, J. B., Esq., F.S.S.
M'Leod, Prof. H., F.R.S.
Ommanney, Admiral Sir E., C.B., F.R.S.
Preece, W. H., Esq., F.R.S.
Roberts-Austen, Prof. W. C., F.R.S.
Rücker, Prof. A. W., F.R.S.
Schuster, Prof. A., F.R.S.
Sidgwick, Prof. H., M.A.
Schäfer, Prof. E. A., F.R.S.
Thorpe, Prof. T. E., F.R.S.
Woodward, Dr. H., F.R.S.

Committees appointed by the General Committee at the Newcastle-upon-Tyne Meeting in September 1889.

1. *Receiving Grants of Money.*

Subject for Investigation or Purpose	Members of the Committee	Grants
		£
Inviting Designs for a good Differential Gravity Meter in supersession of the Pendulum, whereby satisfactory results may be obtained at each station of observation in a few hours instead of the many days over which it is necessary to extend pendulum observations.	*Chairman.*—General J. T. Walker. *Secretary.*—Professor Poynting. Sir William Thomson, Sir J. H. Lefroy, General R. Strachey, Professors A. S. Herschel, G. Chrystal, C. Niven, and A. Schuster, and Mr. C. V. Boys.	10
To co-operate with Dr. Kerr in his researches on Electro-optics.	*Chairman.*—Dr. John Kerr. *Secretary.*—Mr. R. T. Glazebrook. Sir W. Thomson and Professor Rücker.	50
For Calculating Tables of certain Mathematical Functions, and, if necessary, of taking steps to carry out the calculations, and to publish the results in an accessible form.	*Chairman.*—Lord Rayleigh. *Secretary.*—Professor A. Lodge. Sir William Thomson, Professor Cayley, Professor B. Price, and Messrs. J. W. L. Glaisher, A. G. Greenhill, and W. M. Hicks.	25
The Volcanic and Seismological Phenomena of Japan.	*Chairman.*—Sir W. Thomson. *Secretary.*—Professor J. Milne. Professor W. G. Adams, Mr. J. T. Bottomley, and Professor A. H. Green.	75
Carrying on the Tables connected with the Pellian Equation from the point where the work was left by Degen in 1817.	*Chairman.*—Professor Cayley. *Secretary.*—Professor A. Lodge. Professor Sylvester and Mr. A. R. Forsyth.	15
Making Experiments for improving the Construction of Practical Standards for use in Electrical Measurements.	*Chairman.*—Professor Carey Foster. *Secretary.*—Mr. R. T. Glazebrook. Sir William Thomson, Professors Ayrton, J. Perry, W. G. Adams, and Lord Rayleigh, Drs. O. J. Lodge, John Hopkinson, and A. Muirhead, Messrs. W. H. Preece and Herbert Taylor, Professors Everett and Schuster, Dr. J. A. Fleming, Professors G. F. Fitzgerald and Chrystal, Mr. H. Tomlinson, Professors W. Garnett and J. J. Thomson, Messrs. W. N. Shaw, J. T. Bottomley, and T. C. Fitzpatrick, and Professor J. Viriamu Jones.	50

1. *Receiving Grants of Money*—continued.

Subject for Investigation or Purpose	Members of the Committee	Grants
		£
Considering the subject of Electrolysis in its Physical and Chemical Bearings.	*Chairman.*—Professor Fitzgerald. *Secretaries.*—Professors Armstrong and O. J. Lodge. Professors Sir William Thomson, Lord Rayleigh, J. J. Thomson, Schuster, Poynting, Crum Brown, Ramsay, Frankland, Tilden, Hartley, S. P. Thompson, M'Leod, Roberts-Austen, Rücker, Reinold, Carey Foster, and H. B. Dixon, Captain Abney, Drs. Gladstone, Hopkinson, and Fleming, and Messrs. Crookes, Shelford Bidwell, W. N. Shaw, J. Larmor, J. T. Bottomley, R. T. Glazebrook, J. Brown, E. J. Love, and John M. Thomson.	5
The Properties of Solutions . .	*Chairman.*—Professor W. A. Tilden. *Secretary.*—Dr. W. W. J. Nicol. Professor Ramsay.	10
To consider the best Method of establishing an International Standard for the Analysis of Iron and Steel.	*Chairman.*—Professor Roberts-Austen. *Secretary.*—Mr. Thomas Turner. Sir F. Abel, Messrs. E. Riley and J. Spiller, Professor Langley, Mr. G. J. Snelus, and Professor Tilden.	10
Isomeric Naphthalene Derivatives	*Chairman.*—Professor W. A. Tilden. *Secretary.*—Professor H. E. Armstrong.	15
The Influence of the Silent Discharge of Electricity on Oxygen and other gases.	*Chairman.*—Professor H. M'Leod. *Secretary.*—Mr. W. A. Shenstone. Professor Ramsay and Mr. J. T. Cundall.	5
Inquiring into and reporting on the present Methods adopted for teaching Chemistry.	*Chairman.*—Dr. W. J. Russell. *Secretary.*—Professor W. R. Dunstan. Sir H. E. Roscoe, Professor H. E. Armstrong, Professor Meldola, Professor M'Leod, Dr. J. H. Gladstone, Mr. A. G. Vernon Harcourt, Mr. M. M. Pattison Muir, Professor Smithells, Mr. W. A. Shenstone, and Mr. G. Stallard.	10
Absorption Spectra of Pure Compounds.	*Chairman.*—General Festing. *Secretary.*—Dr. H. E. Armstrong. Captain Abney.	30
Conferring with a Committee of the American Association with a view of forming a Uniform System of Recording the Results of Water Analysis.	*Chairman.*—Professor Dewar. *Secretary.*—Professor P. F. Frankland. Professor Odling and Mr. Crookes.	10

1. *Receiving Grants of Money*—continued.

Subject for Investigation or Purpose	Members of the Committee	Grants
		£
The Action of Light on the Hydracids of the Halogens in presence of Oxygen.	*Chairman.*—Dr. Russell. *Secretary.*—Dr. A. Richardson. Captain Abney and Professors Noel Hartley and W. Ramsay.	15
Recording the Position, Height above the sea, Lithological Characters, Size, and Origin of the Erratic Blocks of England, Wales, and Ireland, reporting other matters of interest connected with the same, and taking measures for their preservation.	*Chairman.*—Professor J. Prestwich. *Secretary.*—Dr. H. W. Crosskey. Professors W. Boyd Dawkins, T. McK. Hughes, and T. G. Bonney and Messrs. C. E. De Rance, D. Mackintosh, W. Pengelly, J. Plant, and R. H. Tiddeman.	10
The Volcanic Phenomena of Vesuvius and its neighbourhood.	*Chairman.*—Mr. H. Bauerman. *Secretary.*—Dr. H. J. Johnston-Lavis. Messrs. F. W. Rudler and J. J. H. Teall.	20
The Description and Illustration of the Fossil Phyllopoda of the Palæozoic Rocks.	*Chairman.*—Mr. R. Etheridge. *Secretary.*—Professor T. R. Jones. Dr. H. Woodward.	20
Carrying on the 'Geological Record.'	*Chairman.*—Mr. W. Whitaker. *Secretary.*—Mr. W. Topley. Dr. G. J. Hinde and Messrs. E. T. Newton, R. B. Newton, F. W. Rudler, and J. J. H. Teall.	100
The Circulation of the Underground Waters in the Permeable Formations of England, and the Quality and Quantity of the Waters supplied to various Towns and Districts from these Formations.	*Chairman.*—Professor E. Hull. *Secretary.*—Mr. C. E. De Rance. Dr. H. W. Crosskey, Sir D Galton, Professor J. Prestwich, and Messrs. J. Glaisher, E. B. Marten, G. H. Morton, J. Parker, W. Pengelly, J. Plant, I. Roberts, C. Fox-Strangways, T. S. Stooke, G. J. Symons, W. Topley, Tylden-Wright, E. Wethered, and W. Whitaker.	
To carry on Excavations at Oldbury Hill near Ightham in order to ascertain the existence or otherwise of rock shelters at that spot.	*Chairman.*—Dr. J. Evans. *Secretary.*—Mr. B. Harrison. Professors Prestwich and H. G. Seeley.	15
Preparing a Report on the Cretaceous Polyzoa.	*Chairman.*—Dr. H. Woodward. *Secretary.*—Mr. G. R. Vine. Drs. P. M. Duncan and H. C. Sorby and Mr. C. E. De Rance.	10
The Collection, Preservation and Systematic Registration of Photographs of Geological interest.	*Chairman.*—Professor J. Geikie. *Secretary.*—Mr. O. W. Jeffs. Professors Bonney and Boyd-Dawkins and Messrs. S. A. Adamson, A. S. Reid, and W. Gray.	10

1. *Receiving Grants of Money*—continued.

Subject for Investigation or Purpose	Members of the Committee	Grants
To work the very fossiliferous transition bed between the Middle and Upper Lias in Northamptonshire, in order to obtain a full series of Upper Liassic Gasteropods, and fix the horizon of a fine collection of Liassic Fish.	*Chairman.*—Dr. H. Woodward. *Secretary.*—Mr. Beeby Thompson. Messrs. W. D. Crick, T. G. George, W. Hull, E. A. Walford, E. Wilson, and H. B. Woodward.	£ 25
To arrange for the Occupation of a Table at the Laboratory of the Marine Biological Association at Plymouth, and to nominate students to work thereat.	*Chairman.*—Professor Flower. *Secretary.*—Mr. S. F. Harmer. Professors M. Foster, E. Ray Lankester, and S. H. Vines.	30
For taking steps to establish a Botanical Station at Peradeniya, Ceylon.	*Chairman.*—Professor M. Foster. *Secretary.*—Professor F. O. Bower. Professor Bayley Balfour, Mr. Thiselton-Dyer, Dr. Trimen, Professor Marshall Ward, Mr. Carruthers, and Professor Hartog.	50
To improve and experiment with a Deep-sea Tow-net.	*Chairman.*—Professor Haddon. *Secretary.*—Mr. W. E. Hoyle. Professor W. A. Herdman.	10
To arrange for the Occupation of a Table at the Zoological Station at Naples.	*Chairman.*—Dr. P. L. Sclater. *Secretary.*—Mr. Percy Sladen. Professors E. Ray Lankester, J. Cossar Ewart and M. Foster, Mr. A. Sedgwick, and Professor A. M. Marshall.	100
To report on the present state of our knowledge of the Zoology and Botany of the West India Islands, and to take steps to investigate ascertained deficiencies in the Fauna and Flora.	*Chairman.*—Professor Flower. *Secretary.*—Mr. D. Morris. Mr. Carruthers, Dr. Sclater, Mr. Thiselton-Dyer, Dr. Sharp, Mr. F. Du Cane Godman, Professor Newton, Dr. A. Günther, and Colonel Fielden.	100
The best method of ascertaining and measuring Variations in the Value of the Monetary Standard.	*Chairman.*—Dr. Giffen. *Secretary.*—Prof. F. Y. Edgeworth. Mr. S. Bourne, Professor H. S. Foxwell, Professor Alfred Marshall, Mr. J. B. Martin, Professor J. S. Nicholson, Mr. R. H. Inglis Palgrave, and Professor H. Sidgwick.	10
Inquiring and reporting as to the Statistical Data available for determining the Amount of the Precious Metals in use as Money in the principal countries of the world, the chief forms in which the money is employed, and the amount annually used in the arts.	*Chairman.*—Dr. Giffen. *Secretary.*—Prof. F. Y. Edgeworth. Mr. S. Bourne, Professor H. S. Foxwell, Professor Alfred Marshall, Mr. J. B. Martin, Professor J. S. Nicholson, Mr. R. H. Inglis Palgrave, and Professor H. Sidgwick.	15

1. *Receiving Grants of Money*—continued.

Subject for Investigation or Purpose	Members of the Committee	Grants
		£
The Action of Waves and Currents on the Beds and Foreshores of Estuaries by means of Working Models.	*Chairman.*—Sir J. N. Douglass. *Secretary.*—Professor W. C. Unwin. Professor Osborne Reynolds and Messrs. W. Topley, E. Leader Williams, W. Shelford, G. F. Deacon, A. R. Hunt, W. H. Wheeler, and W. Anderson.	150
To report on the Development of Graphic Methods in Mechanical Science.	*Chairman.*—Mr. W. H. Preece. *Secretary.* — Professor H. S. Hele Shaw. Messrs. B. Baker, W. Anderson, and G. Kapp and Professors J. Perry and R. H. Smith.	25
The Physical Characters, Languages, and Industrial and Social Condition of the North-Western Tribes of the Dominion of Canada.	*Chairman.*—Dr. E. B. Tylor. *Secretary.*—Mr. Bloxam. Sir Daniel Wilson, Dr. G. M. Dawson, General Sir H. Lefroy, and Mr. R. G. Haliburton.	100
The Effects of different Occupations and Employments on the Physical Development of the Human Body.	*Chairman.*—Dr. Beddoe. *Secretary.*—Mr. Bloxam. General Pitt-Rivers, Sir Rawson Rawson, Dr. H. Muirhead, Mr. C. Roberts, Dr. G. W. Hambleton, Mr. F. W. Rudler, and Drs. J. G. Garson, J. Rutherford Morison, and C. S. Jeaffreson.	20
Editing a new Edition of 'Anthropological Notes and Queries.'	*Chairman.*—General Pitt-Rivers. *Secretary.*—Dr. Garson. Dr. Beddoe, Professor Flower, Mr. Francis Galton, and Dr. E. B. Tylor.	50
Calculating the Anthropological Measurements taken in the Anthropometric Laboratory.	*Chairman.*—General Pitt-Rivers. *Secretary.*—Dr. Garson. Mr. Bloxam.	10
The Geography and the Habits, Customs and Physical Characters of the Nomad Tribes of Asia Minor and Northern Persia, and to excavate on sites of Ancient Occupation.	*Chairman.*—Dr. Garson. *Secretary.*—Mr. Bent. Messrs. H. W. Bates, Bloxam and J. Stuart Glennie, Sir Frederic Goldsmid, and Messrs. Pengelly and Rudler.	25
The Habits, Customs, Physical Characteristics and Religions of the natives of India.	*Chairman.*—Sir William Turner. *Secretary.*—Mr. Bloxam. Professor Flower, Dr. E. B. Tylor and Mr. H. H. Risley.	10

1. *Receiving Grants of Money*—continued.

Subject of Investigation or Purpose	Members of the Committee	Grant
		£
For clerical assistance in drawing up the annual report of the Corresponding Societies' Committee.	*Chairman.*—Mr. Francis Galton. *Secretary.*—Professor R. Meldola. Professor A. W. Williamson, Sir Douglas Galton, Professor Boyd Dawkins, Sir Rawson Rawson, Dr. J. G. Garson, Dr. John Evans, Mr. J. Hopkinson, Mr. W. Whitaker, Mr. G. J. Symons, General Pitt-Rivers, Mr. W. Topley, and Professor Bonney.	20

2. *Not receiving Grants of Money.*

Subject for Investigation or Purpose	Members of the Committee
The Collection and Identification of Meteoric Dust.	*Chairman.*—Mr. John Murray. *Secretary.*—Mr. John Murray. Professor Schuster, Sir William Thomson, the Abbé Renard, Mr. A. Buchan, the Hon. R. Abercromby, and Dr. M. Grabham.
The Promotion of Tidal Observations in Canada.	*Chairman.*—Professor Johnson. *Secretary.*—Professor Johnson. Professors Macgregor, J. B. Cherriman, and H. T. Bovey and Mr. C. Carpmael.
The Rate of Increase of Underground Temperature downwards in various Localities of dry Land and under Water.	*Chairman.*—Professor Everett. *Secretary.*—Professor Everett. Professor Sir William Thomson, Mr. G. J. Symons, Sir A. C. Ramsay, Dr. A. Geikie, Mr. J. Glaisher, Mr. Pengelly, Professor Edward Hull, Professor Prestwich, Dr. C. Le Neve Foster, Professor A. S. Herschel, Professor G. A. Lebour, Mr. A. B. Wynne, Mr. Galloway, Mr. Joseph Dickinson, Mr. G. F. Deacon, Mr. E. Wethered, Mr. A. Strahan, and Professor Michie Smith.
Comparing and Reducing Magnetic Observations.	*Chairman.*—Professor W. G. Adams. *Secretary.*—Professor W. G. Adams. Sir W. Thomson, Sir J. H. Lefroy, Professors G. H. Darwin, G. Chrystal, and S. J. Perry, Mr. C. H. Carpmael, Professor Schuster, Mr. G. M. Whipple, Captain Creak, the Astronomer Royal, Mr. William Ellis, Mr. W. Lant Carpenter, and Professor A. W. Rücker.
The Molecular Phenomena connected with the Magnetisation of Iron.	*Chairman.*—Professor Fitzgerald. *Secretary.*—Professor Barrett. Messrs. Trouton and H. F. Newall.

2. *Not receiving Grants of Money*—continued.

Subject for Investigation or Purpose	Members of the Committee
Considering the advisability and possibility of establishing in other parts of the country Observations upon the Prevalence of Earth Tremors similar to those now being made in Durham in connection with coal-mine explosions.	*Chairman.*—Mr. G. J. Symons. *Secretary.*—Professor Lebour. Sir F. J. Bramwell, Mr. E. A. Cowper, Professor G. H. Darwin, Professor Ewing, Mr. Isaac Roberts, Mr. Thomas Gray, Dr. John Evans, Professors Prestwich, Hull, Meldola, and Judd, Mr. M. Walton Brown, and Mr. J. Glaisher.
Seasonal Variations in the Temperatures of Lakes, Rivers, and Estuaries in various parts of the United Kingdom in coöperation with the Local Societies represented on the Association.	*Chairman.*—Mr. John Murray. *Secretary.*—Dr. H. R. Mill. Professor Chrystal, Dr. A. Buchan, the Rev. C. J. Steward, the Hon. R. Abercromby, Mr. J. Y. Buchanan, Mr. David Cunningham, Mr. Isaac Roberts, Professor Fitzgerald, Mr. Sorby, and Mr. Willis Bund.
Considering the best Methods of Recording the Direct Intensity of Solar Radiation.	*Chairman.*—Sir G. G. Stokes. *Secretary.*—Mr. G. J. Symons. Professor Schuster, Mr. G. Johnstone Stoney, Sir H. E. Roscoe, Captain Abney, and Mr. Whipple.
Coöperating with the Scottish Meteorological Society in making Meteorological Observations on Ben Nevis.	*Chairman.*—Hon. R. Abercromby. *Secretary.*—Professor Crum Brown. Messrs. Milne-Home, John Murray, and Buchan and Lord McLaren.
Reporting on the Bibliography of Solution.	*Chairman.*—Professor W. A. Tilden. *Secretary.*—Dr. W. W. J. Nicol. Professors M'Leod, Pickering, Ramsay, and Young and Dr. A. R. Leeds.
The Influence of Silicon on the Properties of Steel.	*Chairman.*—Professor W. A. Tilden. *Secretary.*—Mr. Thomas Turner. Professor Roberts-Austen.
To report on recent inquiries into the History of Chemistry.	*Chairman.*—Professor H. E. Armstrong. *Secretary.*—Professor John Ferguson.
The Continuation of the Bibliography of Spectroscopy.	*Chairman.*—Professor H. M'Leod. *Secretary.*—Professor Roberts-Austen. Professor Reinold and Mr. H. G. Madan.
Preparing a new series of Wave-length Tables of the Spectra of the Elements.	*Chairman.*—Sir H. E. Roscoe. *Secretary.*—Dr. Marshall Watts. Mr. Lockyer, Professors Dewar, Liveing, Schuster, W. N. Hartley, and Wolcott Gibbs, and Captain Abney.
Reporting upon the 'Manure Gravels' of Wexford.	*Chairman.*—Mr. R. Etheridge. *Secretary.*—Mr. A. Bell. Dr. H. Woodward.
An Ancient Sea-beach near Bridlington.	*Chairman.*—Mr. J. W. Davis. *Secretary.*—Mr. G. W. Lamplugh. Mr. W. Cash, Dr. H. Hicks, Mr. Clement Reid, Dr. H. Woodward, and Mr. T. Boynton.

2. *Not receiving Grants of Money.*—continued.

Subject for Investigation or Purpose	Members of the Committee
The Rate of Erosion of the Sea-coasts of England and Wales, and the Influence of the Artificial Abstraction of Shingle or other material in that action.	*Chairman.*—Mr. R. B. Grantham. *Secretaries.*—Messrs. C. E. De Rance and W. Topley. Messrs. J. B. Redman, W. Whitaker, and J. W. Woodall, Maj.-Gen. Sir A. Clarke, Admiral Sir E. Ommanney, Sir J. N. Douglass, Capt. Sir G. Nares, Capt. J. Parsons, Capt. W. J. L. Wharton, Professor J. Prestwich, and Messrs. E. Easton, J. S. Valentine, and L. F. Vernon Harcourt.
Reporting on the Tertiary and Secondary Plants of the United Kingdom, and on the Higher Eocene Beds of the Isle of Wight.	*Chairman.*—Dr. H. Woodward. *Secretary.*—Mr. J. S. Gardner. Professor J. W. Judd and Messrs. W. Carruthers and C. Reid.
To consider the best methods for the registration of all Type Specimens of Fossils in the British Isles, and to report on the same.	*Chairman.*—Dr. Woodward. *Secretary.*—Mr. J. E. Marr. Mr. R. Etheridge, the Rev. G. F. Whidborne, and Mr. R. Kidston.
To make a Digest of the Observations on the Migration of Birds at Lighthouses and Light-vessels, which have been carried on by the Migration Committee of the British Association, and to report upon the same at Leeds.	*Chairman.*—Professor Newton. *Secretary.*—Mr. John Cordeaux. Messrs. John A. Harvie-Brown, R. M. Barrington and W. E. Clarke and the Rev. E. P. Knubley.
Collecting Information as to the Disappearance of Native Plants from their Local Habitats.	*Chairman.*—Mr. A. W. Wills. *Secretary.*—Professor W. Hillhouse. Messrs. E. W. Badger and George Claridge Druce.
The Invertebrate Fauna and Cryptogamic Flora of the Fresh Waters of the British Isles.	*Chairman.*—Canon A. M. Norman. *Secretary.*—Professor J. C. Ewart. Professors I. B. Balfour, J. Geikie, A. C. Haddon, W. R. McNab, W. J. Sollas, and Lapworth, Dr. H. Scott, and Mr. F. E. Beddard.
To reprint the Rules of Zoological Nomenclature, if required.	*Chairman.*—Canon Norman. *Secretary.*—Mr. Howard Saunders. Mr. O. Salvin and Professor Newton.
The Teaching of Science in Elementary Schools.	*Chairman.*—Dr. J. H. Gladstone. *Secretary.*—Professor Armstrong. Mr. S. Bourne, Miss Becker, Sir J. Lubbock, Dr. Crosskey, Sir R. Temple, Sir H. E. Roscoe, Mr. J. Heywood, and Professor N. Story Maskelyne.
Ascertaining and recording the localities in the British Islands in which evidences of the existence of Prehistoric Inhabitants of the country are found.	*Chairman.*—Sir John Lubbock. *Secretary.*—Mr. J. W. Davis. Dr. J. Evans, Professor Boyd Dawkins, Dr. R. Munro, Messrs. Pengelly and Hicks, Professor Meldola, and Dr. Muirhead.

Other Resolutions adopted by the General Committee.

That Mr. J. Larmor be requested to draw up a Report on the present state of our knowledge in Thermodynamics, specially with regard to the second law.

That Mr. W. N. Shaw be requested to continue his Report on the present state of our knowledge in Electrolysis and Electro-chemistry.

That Mr. P. T. Main be requested to continue his Report on our experimental knowledge of the Properties of Matter with respect to Volume, Pressure, Temperature, and Specific Heat.

Communications ordered to be printed in extenso *in the Annual Report of the Association.*

Professor A. B. W. Kennedy's paper 'On the Transmission of Power by Compressed Air (Popp's System).'

Mr. Francis Galton's papers 'On the advisability of assigning Marks for Bodily Efficiency in the Examinations of Candidates for the Public Services,' and 'On the Principle and Methods of assigning Marks for Bodily Efficiency,' together with a full abstract of Mr. Somerville's 'Remarks on the Results of Experiments at Eton College.' [Proofs of these papers to be supplied for present distribution.]

Resolutions referred to the Council for consideration, and action if desirable.

That the Council be recommended to urge upon the Government of India—

(1) The desirability of procuring anthropometric measurements of a representative series of tribes and castes in the Punjab, Bombay, Madras, the Central Provinces, and Assam; it being understood that trained observers are already available.

(2) Also that in the Enumerators' Schedule of the Census of 1891 provision should be made for recording not only the caste to which a man belongs, but also the endogamous and exogamous groups within the caste of which he is a member; it being believed that this was actually done in the last Census of the Punjab, that it will not add to the cost of the Census, and that it will materially enhance its accuracy and scientific value.

That the two following papers be printed *in extenso* in the Report of the Association:—

(1) Professor C. F. Bastable: 'The Incidence and Effects of Import and Export Duties.'

(2) Rev. Dr. Cunningham: 'The Comtist Criticism of Economic Science.'

That the Council of the Association be requested to consider the following Resolutions of the Committee of Section H, and if approved to bring them under the notice of H.M. Civil Service Commissioners and of the chief authorities of the Army, Navy, and Indian Civil Service Departments:—

(1) That the Committee concur in the opinion of H.M. Civil Service Commissioners (Report xxxiii. page 15) that there is no especial difficulty in assigning marks for physical qualifications with adequate precision.

(2) They urge that it is reasonable to include marks for physical qualifications among those by which the place of a candidate is determined in competitive examinations for posts where high physical efficiency is advantageous.

That the Council be requested to urge upon the Canadian Government the desirability of again making a supplementary grant to the Committee appointed for the purpose of investigating the habits, customs, and physical characteristics of the North-Western tribes of the Dominion of Canada, in view of the urgent necessity of pushing forward operations with as much rapidity as possible in consequence of the anticipated speedy extinction of many of the native tribes.

Synopsis of Grants of Money appropriated to Scientific Purposes by the General Committee at the Newcastle-upon-Tyne Meeting, in September, 1889. *The Names of the Members entitled to call on the General Treasurer for the respective Grants are prefixed.*

Mathematics and Physics.

	£	s.	d.
*Walker, General J. T.—Differential Gravity Meter	10	0	0
Kerr, Dr. John.—Electro-optics	50	0	0
*Rayleigh, Lord.—Calculating Tables of certain Mathematical Functions	25	0	0
*Thomson, Sir W.—Volcanic and Seismological Phenomena of Japan	75	0	0
Cayley, Professor.—Pellian Equation Tables	15	0	0
*Foster, Professor G. Carey.—Electrical Standards	50	0	0
*Fitzgerald, Professor.—Electrolysis	5	0	0

Chemistry.

	£	s.	d.
*Tilden, Professor W. A.—Properties of Solutions	10	0	0
*Roberts-Austen, Professor.—Establishing an International Standard for the Analysis of Iron and Steel	10	0	0
*Tilden, Professor W. A.—Isomeric Naphthalene Derivatives	15	0	0
*M'Leod, Professor H.—The Influence of the Silent Discharge of Electricity on Oxygen and other Gases	5	0	0
*Russell, Dr. W. J.—Methods of teaching Chemistry	10	0	0
*Festing, General.—Absorption Spectra	30	0	0
*Dewar, Professor.—Forming a Uniform System of recording the Results of Water Analysis	10	0	0
*Russell, Dr. W. J.—Oxidation of Hydracids in Sunlight	15	0	0

Geology.

	£	s.	d.
*Prestwich, Professor J.—Erratic Blocks	10	0	0
*Bauerman, Mr. H.—Volcanic Phenomena of Vesuvius	20	0	0
*Etheridge, Mr. R.—Fossil Phyllopoda of the Palæozoic Rocks	20	0	0
*Whitaker, Mr. W.—Geological Record	100	0	0
*Hull, Professor E.—Circulation of Underground Waters	5	0	0
Evans, Dr. J.—Excavations at Oldbury Hill	15	0	0
Woodward, Dr. H.—Cretaceous Polyzoa	10	0	0
Carried forward	£510	0	0

* Reappointed.

	£	s.	d.
Brought forward	510	0	0
Geikie, Professor J.—Geological Photographs	10	0	0
Woodward, Dr. H.—Lias Beds of Northamptonshire	25	0	0
Biology.			
*Foster, Professor M.—Botanical Station at Peradeniya	50	0	0
*Haddon, Professor.—To improve and experiment with a Deep-sea Tow-net	10	0	0
*Sclater, Dr. P. L.—Table at the Naples Zoological Station	100	0	0
*Flower, Professor.—Zoology and Botany of the West India Islands	100	0	0
Flower, Professor.—Table at the Laboratory of the Marine Biological Association	30	0	0
Economic Science and Statistics.			
*Giffen, Dr. R.—Variations in the Value of the Monetary Standard	10	0	0
*Giffen, Dr. R.—Precious Metals in Circulation	15	0	0
Mechanical Science.			
*Douglass, Sir J. N.—Action of Waves and Currents in Estuaries	150	0	0
*Preece, Mr. W. H.—Development of Graphic Methods in Mechanical Science	15	0	0
Anthropology.			
*Tylor, Dr. E. B.—North-Western Tribes of Canada	100	0	0
*Beddoe, Dr. J.—Effect of Occupations on Physical Development	20	0	0
*Pitt-Rivers, General.—Editing a New Edition of 'Anthropological Notes and Queries'	50	0	0
*Pitt-Rivers, General.—Anthropometric Calculations	10	0	0
*Garson, Dr.—Geography and Characteristics of Nomad Tribes of Asia Minor and Northern Persia	25	0	0
Turner, Sir W.—Natives of India	10	0	0
*Galton Mr. F.—Corresponding Societies	20	0	0
	£1,265	0	0

* Reappointed.

The Annual Meeting in 1890.

The Meeting at Leeds will commence on Wednesday, September 3.

Place of Meeting in 1891.

The Annual Meeting of the Association will be held at Cardiff.

General Statement of Sums which have been paid on account of Grants for Scientific Purposes.

	£	s.	d.
1834.			
Tide Discussions	20	0	0
1835.			
Tide Discussions	62	0	0
British Fossil Ichthyology	105	0	0
	£167	0	0
1836.			
Tide Discussions	163	0	0
British Fossil Ichthyology	105	0	0
Thermometric Observations, &c.	50	0	0
Experiments on long-continued Heat	17	1	0
Rain-Gauges	9	13	0
Refraction Experiments	15	0	0
Lunar Nutation	60	0	0
Thermometers	15	6	0
	£435	0	0
1837.			
Tide Discussions	284	1	0
Chemical Constants	24	13	6
Lunar Nutation	70	0	0
Observations on Waves	100	12	0
Tides at Bristol	150	0	0
Meteorology and Subterranean Temperature	93	3	0
Vitrification Experiments	150	0	0
Heart Experiments	8	4	6
Barometric Observations	30	0	0
Barometers	11	18	6
	£922	12	6
1838.			
Tide Discussions	29	0	0
British Fossil Fishes	100	0	0
Meteorological Observations and Anemometer (construction)	100	0	0
Cast Iron (Strength of)	60	0	0
Animal and Vegetable Substances (Preservation of)	19	1	10
Railway Constants	41	12	10
Bristol Tides	50	0	0
Growth of Plants	75	0	0
Mud in Rivers	3	6	6
Education Committee	50	0	0
Heart Experiments	5	3	0
Land and Sea Level	267	8	7
Steam-vessels	100	0	0
Meteorological Committee	31	9	5
	£932	2	2
1839.			
Fossil Ichthyology	110	0	0
Meteorological Observations at Plymouth, &c.	63	10	0
Mechanism of Waves	144	2	0
Bristol Tides	35	18	6
Meteorology and Subterranean Temperature	21	11	0
Vitrification Experiments	9	4	7
Cast-Iron Experiments	103	0	0
Railway Constants	28	7	2
Land and Sea Level	274	1	4
Steam-vessels' Engines	100	0	0
Stars in Histoire Céleste	171	18	6
Stars in Lacaille	11	0	0
Stars in R.A.S. Catalogue	166	16	6
Animal Secretions	10	10	0
Steam Engines in Cornwall	50	0	0
Atmospheric Air	16	1	0
Cast and Wrought Iron	40	0	0
Heat on Organic Bodies	3	0	0
Gases on Solar Spectrum	22	0	0
Hourly Meteorological Observations, Inverness and Kingussie	49	7	8
Fossil Reptiles	118	2	9
Mining Statistics	50	0	0
	£1595	11	0
1840.			
Bristol Tides	100	0	0
Subterranean Temperature	13	13	6
Heart Experiments	18	19	0
Lungs Experiments	8	13	0
Tide Discussions	50	0	0
Land and Sea Level	6	11	1
Stars (Histoire Céleste)	242	10	0
Stars (Lacaille)	4	15	0
Stars (Catalogue)	264	0	0
Atmospheric Air	15	15	0
Water on Iron	10	0	0
Heat on Organic Bodies	7	0	0
Meteorological Observations	52	17	6
Foreign Scientific Memoirs	112	1	6
Working Population	100	0	0
School Statistics	50	0	0
Forms of Vessels	184	7	0
Chemical and Electrical Phenomena	40	0	0
Meteorological Observations at Plymouth	80	0	0
Magnetical Observations	185	13	9
	£1546	16	4
1841.			
Observations on Waves	30	0	0
Meteorology and Subterranean Temperature	8	8	0
Actinometers	10	0	0
Earthquake Shocks	17	7	0
Acrid Poisons	6	0	0
Veins and Absorbents	3	0	0
Mud in Rivers	5	0	0

	£	s.	d.
Marine Zoology	15	12	8
Skeleton Maps	20	0	0
Mountain Barometers	6	18	6
Stars (Histoire Céleste)	185	0	0
Stars (Lacaille)	79	5	0
Stars (Nomenclature of)	17	19	6
Stars (Catalogue of)	40	0	0
Water on Iron	50	0	0
Meteorological Observations at Inverness	20	0	0
Meteorological Observations (reduction of)	25	0	0
Fossil Reptiles	50	0	0
Foreign Memoirs	62	0	6
Railway Sections	38	1	0
Forms of Vessels	193	12	0
Meteorological Observations at Plymouth	55	0	0
Magnetical Observations	61	18	8
Fishes of the Old Red Sandstone	100	0	0
Tides at Leith	50	0	0
Anemometer at Edinburgh	69	1	10
Tabulating Observations	9	6	3
Races of Men	5	0	0
Radiate Animals	2	0	0
	£1235	10	11

1842.

	£	s.	d.
Dynamometric Instruments	113	11	2
Anoplura Britanniæ	52	12	0
Tides at Bristol	59	8	0
Gases on Light	30	14	7
Chronometers	26	17	6
Marine Zoology	1	5	0
British Fossil Mammalia	100	0	0
Statistics of Education	20	0	0
Marine Steam-vessels' Engines	28	0	0
Stars (Histoire Céleste)	59	0	0
Stars (Brit. Assoc. Cat. of)	110	0	0
Railway Sections	161	10	0
British Belemnites	50	0	0
Fossil Reptiles (publication of Report)	210	0	0
Forms of Vessels	180	0	0
Galvanic Experiments on Rocks	5	8	6
Meteorological Experiments at Plymouth	68	0	0
Constant Indicator and Dynamometric Instruments	90	0	0
Force of Wind	10	0	0
Light on Growth of Seeds	8	0	0
Vital Statistics	50	0	0
Vegetative Power of Seeds	8	1	11
Questions on Human Race	7	9	0
	£1449	17	8

1843.

	£	s.	d.
Revision of the Nomenclature of Stars	2	0	0
Reduction of Stars, British Association Catalogue	25	0	0
Anomalous Tides, Frith of Forth	120	0	0
Hourly Meteorological Observations at Kingussie and Inverness	77	12	8
Meteorological Observations at Plymouth	55	0	0
Whewell's Meteorological Anemometer at Plymouth	10	0	0
Meteorological Observations, Osler's Anemometer at Plymouth	20	0	0
Reduction of Meteorological Observations	30	0	0
Meteorological Instruments and Gratuities	39	6	0
Construction of Anemometer at Inverness	56	12	2
Magnetic Co-operation	10	8	10
Meteorological Recorder for Kew Observatory	50	0	0
Action of Gases on Light	18	16	1
Establishment at Kew Observatory, Wages, Repairs, Furniture, and Sundries	133	4	7
Experiments by Captive Balloons	81	8	0
Oxidation of the Rails of Railways	20	0	0
Publication of Report on Fossil Reptiles	40	0	0
Coloured Drawings of Railway Sections	147	18	3
Registration of Earthquake Shocks	30	0	0
Report on Zoological Nomenclature	10	0	0
Uncovering Lower Red Sandstone near Manchester	4	4	6
Vegetative Power of Seeds	5	3	8
Marine Testacea (Habits of)	10	0	0
Marine Zoology	10	0	0
Marine Zoology	2	14	11
Preparation of Report on British Fossil Mammalia	100	0	0
Physiological Operations of Medicinal Agents	20	0	0
Vital Statistics	36	5	8
Additional Experiments on the Forms of Vessels	70	0	0
Additional Experiments on the forms of Vessels	100	0	0
Reduction of Experiments on the Forms of Vessels	100	0	0
Morin's Instrument and Constant Indicator	69	14	10
Experiments on the Strength of Materials	60	0	0
	£1565	10	2

1844.	£	s.	d.
Meteorological Observations at Kingussie and Inverness	12	0	0
Completing Observations at Plymouth	35	0	0
Magnetic and Meteorological Co-operation	25	8	4
Publication of the British Association Catalogue of Stars	35	0	0
Observations on Tides on the East Coast of Scotland	100	0	0
Revision of the Nomenclature of Stars 1842	2	9	6
Maintaining the Establishment in Kew Observatory	117	17	3
Instruments for Kew Observatory	56	7	3
Influence of Light on Plants	10	0	0
Subterraneous Temperature in Ireland	5	0	0
Coloured Drawings of Railway Sections	15	17	6
Investigation of Fossil Fishes of the Lower Tertiary Strata	100	0	0
Registering the Shocks of Earthquakes 1842	23	11	10
Structure of Fossil Shells	20	0	0
Radiata and Mollusca of the Ægean and Red Seas 1842	100	0	0
Geographical Distributions of Marine Zoology......1842	0	10	0
Marine Zoology of Devon and Cornwall	10	0	0
Marine Zoology of Corfu	10	0	0
Experiments on the Vitality of Seeds	9	0	0
Experiments on the Vitality of Seeds 1842	8	7	3
Exotic Anoplura	15	0	0
Strength of Materials	100	0	0
Completing Experiments on the Forms of Ships	100	0	0
Inquiries into Asphyxia	10	0	0
Investigations on the Internal Constitution of Metals	50	0	0
Constant Indicator and Morin's Instrument 1842	10	0	0
	£981	12	8

1845.	£	s.	d.
Publication of the British Association Catalogue of Stars	351	14	6
Meteorological Observations at Inverness	30	18	11
Magnetic and Meteorological Co-operation	16	16	8
Meteorological Instruments at Edinburgh	18	11	9
Reduction of Anemometrical Observations at Plymouth	25	0	0
Electrical Experiments at Kew Observatory	43	17	8
Maintaining the Establishment in Kew Observatory	149	15	0
For Kreil's Barometrograph	25	0	0
Gases from Iron Furnaces	50	0	0
The Actinograph	15	0	0
Microscopic Structure of Shells	20	0	0
Exotic Anoplura 1843	10	0	0
Vitality of Seeds 1843	2	0	7
Vitality of Seeds 1844	7	0	0
Marine Zoology of Cornwall	10	0	0
Physiological Action of Medicines	20	0	0
Statistics of Sickness and Mortality in York	20	0	0
Earthquake Shocks 1843	15	14	8
	£831	9	9

1846.	£	s.	d.
British Association Catalogue of Stars 1844	211	15	0
Fossil Fishes of the London Clay	100	0	0
Computation of the Gaussian Constants for 1829	5	0	0
Maintaining the Establishment at Kew Observatory	146	16	7
Strength of Materials	60	0	0
Researches in Asphyxia	6	16	2
Examination of Fossil Shells	10	0	0
Vitality of Seeds 1844	2	15	10
Vitality of Seeds 1845	7	12	3
Marine Zoology of Cornwall	10	0	0
Marine Zoology of Britain	10	0	0
Exotic Anoplura 1844	25	0	0
Expenses attending Anemometers	11	7	6
Anemometers' Repairs	2	3	6
Atmospheric Waves	3	3	3
Captive Balloons 1844	8	19	8
Varieties of the Human Race 1844	7	6	3
Statistics of Sickness and Mortality in York	12	0	0
	£685	16	0

1847.	£	s.	d.
Computation of the Gaussian Constants for 1829	50	0	0
Habits of Marine Animals	10	0	0
Physiological Action of Medicines	20	0	0
Marine Zoology of Cornwall	10	0	0
Atmospheric Waves	6	9	3
Vitality of Seeds	4	7	7
Maintaining the Establishment at Kew Observatory	107	8	6
	£208	5	4

	£	s.	d.
1848.			
Maintaining the Establishment at Kew Observatory	171	15	11
Atmospheric Waves	3	10	9
Vitality of Seeds	9	15	0
Completion of Catalogue of Stars	70	0	0
On Colouring Matters	5	0	0
On Growth of Plants	15	0	0
	£275	1	8
1849.			
Electrical Observations at Kew Observatory	50	0	0
Maintaining the Establishment at ditto	76	2	5
Vitality of Seeds	5	8	1
On Growth of Plants	5	0	0
Registration of Periodical Phenomena	10	0	0
Bill on Account of Anemometrical Observations	13	9	0
	£159	19	6
1850.			
Maintaining the Establishment at Kew Observatory	255	18	0
Transit of Earthquake Waves	50	0	0
Periodical Phenomena	15	0	0
Meteorological Instruments, Azores	25	0	0
	£345	18	0
1851.			
Maintaining the Establishment at Kew Observatory (includes part of grant in 1849)	309	2	2
Theory of Heat	20	1	1
Periodical Phenomena of Animals and Plants	5	0	0
Vitality of Seeds	5	6	4
Influence of Solar Radiation	30	0	0
Ethnological Inquiries	12	0	0
Researches on Annelida	10	0	0
	£391	9	7
1852.			
Maintaining the Establishment at Kew Observatory (including balance of grant for 1850)	233	17	8
Experiments on the Conduction of Heat	5	2	9
Influence of Solar Radiations	20	0	0
Geological Map of Ireland	15	0	0
Researches on the British Annelida	10	0	0
Vitality of Seeds	10	6	2
Strength of Boiler Plates	10	0	0
	£304	6	7
1853.			
Maintaining the Establishment at Kew Observatory	165	0	0
Experiments on the Influence of Solar Radiation	15	0	0
Researches on the British Annelida	10	0	0
Dredging on the East Coast of Scotland	10	0	0
Ethnological Queries	5	0	0
	£205	0	0
1854.			
Maintaining the Establishment at Kew Observatory (including balance of former grant)	330	15	4
Investigations on Flax	11	0	0
Effects of Temperature on Wrought Iron	10	0	0
Registration of Periodical Phenomena	10	0	0
British Annelida	10	0	0
Vitality of Seeds	5	2	3
Conduction of Heat	4	2	0
	£380	19	7
1855.			
Maintaining the Establishment at Kew Observatory	425	0	0
Earthquake Movements	10	0	0
Physical Aspect of the Moon	11	8	5
Vitality of Seeds	10	7	11
Map of the World	15	0	0
Ethnological Queries	5	0	0
Dredging near Belfast	4	0	0
	£480	16	4
1856.			
Maintaining the Establishment at Kew Observatory :— 1854 .... £ 75 0 0; 1855 .... £500 0 0	575	0	0
Strickland's Ornithological Synonyms	100	0	0
Dredging and Dredging Forms	9	13	0
Chemical Action of Light	20	0	0
Strength of Iron Plates	10	0	0
Registration of Periodical Phenomena	10	0	0
Propagation of Salmon	10	0	0
	£734	13	9
1857.			
Maintaining the Establishment at Kew Observatory	350	0	0
Earthquake Wave Experiments	40	0	0
Dredging near Belfast	10	0	0
Dredging on the West Coast of Scotland	10	0	0

	£	s.	d.
Investigations into the Mollusca of California	10	0	0
Experiments on Flax	5	0	0
Natural History of Madagascar	20	0	0
Researches on British Annelida	25	0	0
Report on Natural Products imported into Liverpool	10	0	0
Artificial Propagation of Salmon	10	0	0
Temperature of Mines	7	8	0
Thermometers for Subterranean Observations	5	7	4
Life-boats	5	0	0
	£507	15	4

1858.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	500	0	0
Earthquake Wave Experiments	25	0	0
Dredging on the West Coast of Scotland	10	0	0
Dredging near Dublin	5	0	0
Vitality of Seeds	5	5	0
Dredging near Belfast	18	13	2
Report on the British Annelida	25	0	0
Experiments on the production of Heat by Motion in Fluids	20	0	0
Report on the Natural Products imported into Scotland	10	0	0
	£618	18	2

1859.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	500	0	0
Dredging near Dublin	15	0	0
Osteology of Birds	50	0	0
Irish Tunicata	5	0	0
Manure Experiments	20	0	0
British Medusidæ	5	0	0
Dredging Committee	5	0	0
Steam-vessels' Performance	5	0	0
Marine Fauna of South and West of Ireland	10	0	0
Photographic Chemistry	10	0	0
Lanarkshire Fossils	20	0	1
Balloon Ascents	39	11	0
	£684	11	1

1860.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	500	0	0
Dredging near Belfast	16	6	0
Dredging in Dublin Bay	15	0	0
Inquiry into the Performance of Steam-vessels	124	0	0
Explorations in the Yellow Sandstone of Dura Den	20	0	0
Chemico-mechanical Analysis of Rocks and Minerals	25	0	0
Researches on the Growth of Plants	10	0	0
Researches on the Solubility of Salts	30	0	0
Researches on the Constituents of Manures	25	0	0
Balance of Captive Balloon Accounts	1	13	6
	£766	19	6

1861.

	£	s.	d.
Maintaining the Establishment of Kew Observatory	500	0	0
Earthquake Experiments	25	0	0
Dredging North and East Coasts of Scotland	23	0	0
Dredging Committee:— 1860......£50 0 0; 1861......£22 0 0	72	0	0
Excavations at Dura Den	20	0	0
Solubility of Salts	20	0	0
Steam-vessel Performance	150	0	0
Fossils of Lesmahago	15	0	0
Explorations at Uriconium	20	0	0
Chemical Alloys	20	0	0
Classified Index to the Transactions	100	0	0
Dredging in the Mersey and Dee	5	0	0
Dip Circle	30	0	0
Photoheliographic Observations	50	0	0
Prison Diet	20	0	0
Gauging of Water	10	0	0
Alpine Ascents	6	5	10
Constituents of Manures	25	0	0
	£1111	5	10

1862.

	£	s.	d.
Maintaining the Establishment of Kew Observatory	500	0	0
Patent Laws	21	6	0
Mollusca of N.-W. of America	10	0	0
Natural History by Mercantile Marine	5	0	0
Tidal Observations	25	0	0
Photoheliometer at Kew	40	0	0
Photographic Pictures of the Sun	150	0	0
Rocks of Donegal	25	0	0
Dredging Durham and Northumberland	25	0	0
Connection of Storms	20	0	0
Dredging North-east Coast of Scotland	6	9	6
Ravages of Teredo	3	11	0
Standards of Electrical Resistance	50	0	0
Railway Accidents	10	0	0
Balloon Committee	200	0	0
Dredging Dublin Bay	10	0	0

	£	s.	d.
Dredging the Mersey	5	0	0
Prison Diet	20	0	0
Gauging of Water	12	10	0
Steamships' Performance	150	0	0
Thermo-Electric Currents	5	0	0
	£1293	16	6

1863.

	£	s.	d.
Maintaining the Establishment of Kew Observatory	600	0	0
Balloon Committee deficiency	70	0	0
Balloon Ascents (other expenses)	25	0	0
Entozoa	25	0	0
Coal Fossils	20	0	0
Herrings	20	0	0
Granites of Donegal	5	0	0
Prison Diet	20	0	0
Vertical Atmospheric Movements	13	0	0
Dredging Shetland	50	0	0
Dredging North-east coast of Scotland	25	0	0
Dredging Northumberland and Durham	17	3	10
Dredging Committee superintendence	10	0	0
Steamship Performance	100	0	0
Balloon Committee	200	0	0
Carbon under pressure	10	0	0
Volcanic Temperature	100	0	0
Bromide of Ammonium	8	0	0
Electrical Standards	100	0	0
Electrical Construction and Distribution	40	0	0
Luminous Meteors	17	0	0
Kew Additional Buildings for Photoheliograph	100	0	0
Thermo-Electricity	15	0	0
Analysis of Rocks	8	0	0
Hydroida	10	0	0
	£1608	3	10

1864.

	£	s.	d.
Maintaining the Establishment of Kew Observatory	600	0	0
Coal Fossils	20	0	0
Vertical Atmospheric Movements	20	0	0
Dredging Shetland	75	0	0
Dredging Northumberland	25	0	0
Balloon Committee	200	0	0
Carbon under pressure	10	0	0
Standards of Electric Resistance	100	0	0
Analysis of Rocks	10	0	0
Hydroida	10	0	0
Askham's Gift	50	0	0
Nitrite of Amyle	10	0	0
Nomenclature Committee	5	0	0
Rain-Gauges	19	15	8
Cast-Iron Investigation	20	0	0
Tidal Observations in the Humber	50	0	0
Spectral Rays	45	0	0
Luminous Meteors	20	0	0
	£1289	15	8

1865.

	£	s.	d.
Maintaining the Establishment of Kew Observatory	600	0	0
Balloon Committee	100	0	0
Hydroida	13	0	0
Rain-Gauges	30	0	0
Tidal Observations in the Humber	6	8	0
Hexylic Compounds	20	0	0
Amyl Compounds	20	0	0
Irish Flora	25	0	0
American Mollusca	3	9	0
Organic Acids	20	0	0
Lingula Flags Excavation	10	0	0
Eurypterus	50	0	0
Electrical Standards	100	0	0
Malta Caves Researches	30	0	0
Oyster Breeding	25	0	0
Gibraltar Caves Researches	150	0	0
Kent's Hole Excavations	100	0	0
Moon's Surface Observations	35	0	0
Marine Fauna	25	0	0
Dredging Aberdeenshire	25	0	0
Dredging Channel Islands	50	0	0
Zoological Nomenclature	5	0	0
Resistance of Floating Bodies in Water	100	0	0
Bath Waters Analysis	8	10	10
Luminous Meteors	40	0	0
	£1591	7	10

1866.

	£	s.	d.
Maintaining the Establishment of Kew Observatory	600	0	0
Lunar Committee	64	13	4
Balloon Committee	50	0	0
Metrical Committee	50	0	0
British Rainfall	50	0	0
Kilkenny Coal Fields	16	0	0
Alum Bay Fossil Leaf-Bed	15	0	0
Luminous Meteors	50	0	0
Lingula Flags Excavation	20	0	0
Chemical Constitution of Cast Iron	50	0	0
Amyl Compounds	25	0	0
Electrical Standards	100	0	0
Malta Caves Exploration	30	0	0
Kent's Hole Exploration	200	0	0
Marine Fauna, &c., Devon and Cornwall	25	0	0
Dredging Aberdeenshire Coast	25	0	0
Dredging Hebrides Coast	50	0	0
Dredging the Mersey	5	0	0
Resistance of Floating Bodies in Water	50	0	0
Polycyanides of Organic Radicals	29	0	0

	£	s.	d.
Rigor Mortis	10	0	0
Irish Annelida	15	0	0
Catalogue of Crania	50	0	0
Didine Birds of Mascarene Islands	50	0	0
Typical Crania Researches	30	0	0
Palestine Exploration Fund	100	0	0
	£1750	13	4

1867.

	£	s.	d.
Maintaining the Establishment of Kew Observatory	600	0	0
Meteorological Instruments, Palestine	50	0	0
Lunar Committee	120	0	0
Metrical Committee	30	0	0
Kent's Hole Explorations	100	0	0
Palestine Explorations	50	0	0
Insect Fauna, Palestine	30	0	0
British Rainfall	50	0	0
Kilkenny Coal Fields	25	0	0
Alum Bay Fossil Leaf-Bed	25	0	0
Luminous Meteors	50	0	0
Bournemouth, &c., Leaf-Beds	30	0	0
Dredging Shetland	75	0	0
Steamship Reports Condensation	100	0	0
Electrical Standards	100	0	0
Ethyl and Methyl series	25	0	0
Fossil Crustacea	25	0	0
Sound under Water	24	4	0
North Greenland Fauna	75	0	0
Do. Plant Beds	100	0	0
Iron and Steel Manufacture	25	0	0
Patent Laws	30	0	0
	£1739	4	0

1868.

	£	s.	d.
Maintaining the Establishment of Kew Observatory	600	0	0
Lunar Committee	120	0	0
Metrical Committee	50	0	0
Zoological Record	100	0	0
Kent's Hole Explorations	150	0	0
Steamship Performances	100	0	0
British Rainfall	50	0	0
Luminous Meteors	50	0	0
Organic Acids	60	0	0
Fossil Crustacea	25	0	0
Methyl Series	25	0	0
Mercury and Bile	25	0	0
Organic Remains in Limestone Rocks	25	0	0
Scottish Earthquakes	20	0	0
Fauna, Devon and Cornwall	30	0	0
British Fossil Corals	50	0	0
Bagshot Leaf-Beds	50	0	0
Greenland Explorations	100	0	0
Fossil Flora	25	0	0
Tidal Observations	100	0	0
Underground Temperature	50	0	0
Spectroscopic Investigations of Animal Substances	5	0	0
Secondary Reptiles, &c.	30	0	0
British Marine Invertebrate Fauna	100	0	0
	£1940	0	0

1869.

	£	s.	d.
Maintaining the Establishment of Kew Observatory	600	0	0
Lunar Committee	50	0	0
Metrical Committee	25	0	0
Zoological Record	100	0	0
Committee on Gases in Deep-well Water	25	0	0
British Rainfall	50	0	0
Thermal Conductivity of Iron, &c.	30	0	0
Kent's Hole Explorations	150	0	0
Steamship Performances	30	0	0
Chemical Constitution of Cast Iron	80	0	0
Iron and Steel Manufacture	100	0	0
Methyl Series	30	0	0
Organic Remains in Limestone Rocks	10	0	0
Earthquakes in Scotland	10	0	0
British Fossil Corals	50	0	0
Bagshot Leaf-Beds	30	0	0
Fossil Flora	25	0	0
Tidal Observations	100	0	0
Underground Temperature	30	0	0
Spectroscopic Investigations of Animal Substances	5	0	0
Organic Acids	12	0	0
Kiltorcan Fossils	20	0	0
Chemical Constitution and Physiological Action Relations	15	0	0
Mountain Limestone Fossils	25	0	0
Utilization of Sewage	10	0	0
Products of Digestion	10	0	0
	£1622	0	0

1870.

	£	s.	d.
Maintaining the Establishment of Kew Observatory	600	0	0
Metrical Committee	25	0	0
Zoological Record	100	0	0
Committee on Marine Fauna	20	0	0
Ears in Fishes	10	0	0
Chemical Nature of Cast Iron	80	0	0
Luminous Meteors	30	0	0
Heat in the Blood	15	0	0
British Rainfall	100	0	0
Thermal Conductivity of Iron, &c.	20	0	0
British Fossil Corals	50	0	0
Kent's Hole Explorations	150	0	0
Scottish Earthquakes	4	0	0
Bagshot Leaf-Beds	15	0	0
Fossil Flora	25	0	0
Tidal Observations	100	0	0
Underground Temperature	50	0	0
Kiltorcan Quarries Fossils	20	0	0

	£	s.	d.
Mountain Limestone Fossils	25	0	0
Utilization of Sewage	50	0	0
Organic Chemical Compounds	30	0	0
Onny River Sediment	3	0	0
Mechanical Equivalent of Heat..............................	50	0	0
	£1572	0	0

1871.

	£	s.	d.
Maintaining the Establishment of Kew Observatory	600	0	0
Monthly Reports of Progress in Chemistry	100	0	0
Metrical Committee............	25	0	0
Zoological Record...............	100	0	0
Thermal Equivalents of the Oxides of Chlorine	10	0	0
Tidal Observations	100	0	0
Fossil Flora	25	0	0
Luminous Meteors	30	0	0
British Fossil Corals	25	0	0
Heat in the Blood...............	7	2	6
British Rainfall..................	50	0	0
Kent's Hole Explorations ...	150	0	0
Fossil Crustacea	25	0	0
Methyl Compounds	25	0	0
Lunar Objects	20	0	0
Fossil Coral Sections, for Photographing	20	0	0
Bagshot Leaf-Beds	20	0	0
Moab Explorations	100	0	0
Gaussian Constants	40	0	0
	£1472	2	6

1872.

	£	s.	d.
Maintaining the Establishment of Kew Observatory	300	0	0
Metrical Committee............	75	0	0
Zoological Record...............	100	0	0
Tidal Committee	200	0	0
Carboniferous Corals	25	0	0
Organic Chemical Compounds	25	0	0
Exploration of Moab............	100	0	0
Terato-Embryological Inquiries	10	0	0
Kent's Cavern Exploration..	100	0	0
Luminous Meteors	20	0	0
Heat in the Blood...............	15	0	0
Fossil Crustacea	25	0	0
Fossil Elephants of Malta ...	25	0	0
Lunar Objects	20	0	0
Inverse Wave-Lengths.........	20	0	0
British Rainfall..................	100	0	0
Poisonous Substances Antagonism..............................	10	0	0
Essential Oils, Chemical Constitution, &c.	40	0	0
Mathematical Tables	50	0	0
Thermal Conductivity of Metals	25	0	0
	£1285	0	0

1873.

	£	s.	d.
Zoological Record...............	100	0	0
Chemistry Record...............	200	0	0
Tidal Committee	400	0	0
Sewage Committee	100	0	0
Kent's Cavern Exploration ...	150	0	0
Carboniferous Corals	25	0	0
Fossil Elephants	25	0	0
Wave-Lengths	150	0	0
British Rainfall..................	100	0	0
Essential Oils.....................	30	0	0
Mathematical Tables	100	0	0
Gaussian Constants	10	0	0
Sub-Wealden Explorations...	25	0	0
Underground Temperature ...	150	0	0
Settle Cave Exploration	50	0	0
Fossil Flora, Ireland............	20	0	0
Timber Denudation and Rainfall	20	0	0
Luminous Meteors...............	30	0	0
	£1685	0	0

1874.

	£	s.	d.
Zoological Record...............	100	0	0
Chemistry Record...............	100	0	0
Mathematical Tables	100	0	0
Elliptic Functions..............	100	0	0
Lightning Conductors	10	0	0
Thermal Conductivity of Rocks	10	0	0
Anthropological Instructions, &c.	50	0	0
Kent's Cavern Exploration...	150	0	0
Luminous Meteors	30	0	0
Intestinal Secretions	15	0	0
British Rainfall..................	100	0	0
Essential Oils.....................	10	0	0
Sub-Wealden Explorations ...	25	0	0
Settle Cave Exploration	50	0	0
Mauritius Meteorological Research	100	0	0
Magnetization of Iron	20	0	0
Marine Organisms...............	30	0	0
Fossils, North-West of Scotland	2	10	0
Physiological Action of Light	20	0	0
Trades Unions	25	0	0
Mountain Limestone-Corals	25	0	0
Erratic Blocks	10	0	0
Dredging, Durham and Yorkshire Coasts	28	5	0
High Temperature of Bodies	30	0	0
Siemens's Pyrometer	3	6	0
Labyrinthodonts of Coal-Measures........................	7	15	0
	£1151	16	0

1875.

	£	s.	d.
Elliptic Functions	100	0	0
Magnetization of Iron	20	0	0
British Rainfall	120	0	0
Luminous Meteors	30	0	0
Chemistry Record...............	100	0	0

	£	s.	d.
Specific Volume of Liquids...	25	0	0
Estimation of Potash and Phosphoric Acid..............	10	0	0
Isometric Cresols	20	0	0
Sub-Wealden Explorations ...	100	0	0
Kent's Cavern Exploration...	100	0	0
Settle Cave Exploration	50	0	0
Earthquakes in Scotland......	15	0	0
Underground Waters	10	0	0
Development of Myxinoid Fishes	20	0	0
Zoological Record..............	100	0	0
Instructions for Travellers ...	20	0	0
Intestinal Secretions	20	0	0
Palestine Exploration	100	0	0
	£960	0	0

1876.

	£	s.	d.
Printing Mathematical Tables	159	4	2
British Rainfall..................	100	0	0
Ohm's Law........................	9	15	0
Tide Calculating Machine ...	200	0	0
Specific Volume of Liquids...	25	0	0
Isomeric Cresols	10	0	0
Action of Ethyl Bromobutyrate on Ethyl Sodaceto-acetate..........................	5	0	0
Estimation of Potash and Phosphoric Acid..............	13	0	0
Exploration of Victoria Cave, Settle	100	0	0
Geological Record..............	100	0	0
Kent's Cavern Exploration...	100	0	0
Thermal Conductivities of Rocks	10	0	0
Underground Waters	10	0	0
Earthquakes in Scotland......	1	10	0
Zoological Record..............	100	0	0
Close Time	5	0	0
Physiological Action of Sound	25	0	0
Zoological Station..............	75	0	0
Intestinal Secretions	15	0	0
Physical Characters of Inhabitants of British Isles......	13	15	0
Measuring Speed of Ships ...	10	0	0
Effect of Propeller on turning of Steam Vessels	5	0	0
	£1092	4	2

1877.

	£	s.	d.
Liquid Carbonic Acids in Minerals	20	0	0
Elliptic Functions	250	0	0
Thermal Conductivity of Rocks	9	11	7
Zoological Record..............	100	0	0
Kent's Cavern	100	0	0
Zoological Station at Naples	75	0	0
Luminous Meteors	30	0	0
Elasticity of Wires	100	0	0
Dipterocarpæ, Report on......	20	0	0
Mechanical Equivalent of Heat............................	35	0	0
Double Compounds of Cobalt and Nickel	8	0	0
Underground Temperatures	50	0	0
Settle Cave Exploration	100	0	0
Underground Waters in New Red Sandstone	10	0	0
Action of Ethyl Bromobutyrate on Ethyl Sodaceto-acetate	10	0	0
British Earthworks	25	0	0
Atmospheric Elasticity in India	15	0	0
Development of Light from Coal-gas	20	0	0
Estimation of Potash and Phosphoric Acid..............	1	18	0
Geological Record..............	100	0	0
Anthropometric Committee	34	0	0
Physiological Action of Phosphoric Acid, &c................	15	0	0
	£1128	9	7

1878.

	£	s.	d.
Exploration of Settle Caves	100	0	0
Geological Record..............	100	0	0
Investigation of Pulse Phenomena by means of Syphon Recorder	10	0	0
Zoological Station at Naples	75	0	0
Investigation of Underground Waters..........................	15	0	0
Transmission of Electrical Impulses through Nerve Structure........................	30	0	0
Calculation of Factor Table of Fourth Million	100	0	0
Anthropometric Committee...	66	0	0
Chemical Composition and Structure of less known Alkaloids...........	25	0	0
Exploration of Kent's Cavern	50	0	0
Zoological Record	100	0	0
Fermanagh Caves Exploration	15	0	0
Thermal Conductivity of Rocks	4	16	6
Luminous Meteors...............	10	0	0
Ancient Earthworks	25	0	0
	£725	16	6

1879.

	£	s.	d.
Table at the Zoological Station, Naples	75	0	0
Miocene Flora of the Basalt of the North of Ireland ...	20	0	0
Illustrations for a Monograph on the Mammoth	17	0	0
Record of Zoological Literature	100	0	0
Composition and Structure of less-known Alkaloids	25	0	0

	£	s.	d.
Exploration of Caves in Borneo	50	0	0
Kent's Cavern Exploration	100	0	0
Record of the Progress of Geology	100	0	0
Fermanagh Caves Exploration	5	0	0
Electrolysis of Metallic Solutions and Solutions of Compound Salts	25	0	0
Anthropometric Committee	50	0	0
Natural History of Socotra	100	0	0
Calculation of Factor Tables for 5th and 6th Millions	150	0	0
Circulation of Underground Waters	10	0	0
Steering of Screw Steamers	10	0	0
Improvements in Astronomical Clocks	30	0	0
Marine Zoology of South Devon	20	0	0
Determination of Mechanical Equivalent of Heat	12	15	6
Specific Inductive Capacity of Sprengel Vacuum	40	0	0
Tables of Sun-heat Coefficients	30	0	0
Datum Level of the Ordnance Survey	10	0	0
Tables of Fundamental Invariants of Algebraic Forms	36	14	9
Atmospheric Electricity Observations in Madeira	15	0	0
Instrument for Detecting Fire-damp in Mines	22	0	0
Instruments for Measuring the Speed of Ships	17	1	8
Tidal Observations in the English Channel	10	0	0
	£1080	11	11

1880.

	£	s.	d.
New Form of High Insulation Key	10	0	0
Underground Temperature	10	0	0
Determination of the Mechanical Equivalent of Heat	8	5	0
Elasticity of Wires	50	0	0
Luminous Meteors	30	0	0
Lunar Disturbance of Gravity	30	0	0
Fundamental Invariants	8	5	0
Laws of Water Friction	20	0	0
Specific Inductive Capacity of Sprengel Vacuum	20	0	0
Completion of Tables of Sun-heat Coefficients	50	0	0
Instrument for Detection of Fire-damp in Mines	10	0	0
Inductive Capacity of Crystals and Paraffines	4	17	7
Report on Carboniferous Polyzoa	10	0	0
Caves of South Ireland	10	0	0
Viviparous Nature of Ichthyosaurus	10	0	0
Kent's Cavern Exploration	50	0	0
Geological Record	100	0	0
Miocene Flora of the Basalt of North Ireland	15	0	0
Underground Waters of Permian Formations	5	0	0
Record of Zoological Literature	100	0	0
Table at Zoological Station at Naples	75	0	0
Investigation of the Geology and Zoology of Mexico	50	0	0
Anthropometry	50	0	0
Patent Laws	5	0	0
	£731	7	7

1881.

	£	s.	d.
Lunar Disturbance of Gravity	30	0	0
Underground Temperature	20	0	0
High Insulation Key	5	0	0
Tidal Observations	10	0	0
Fossil Polyzoa	10	0	0
Underground Waters	10	0	0
Earthquakes in Japan	25	0	0
Tertiary Flora	20	0	0
Scottish Zoological Station	50	0	0
Naples Zoological Station	75	0	0
Natural History of Socotra	50	0	0
Zoological Record	100	0	0
Weights and Heights of Human Beings	30	0	0
Electrical Standards	25	0	0
Anthropological Notes and Queries	9	0	0
Specific Refractions	7	3	1
	£476	3	1

1882.

	£	s.	d.
Tertiary Flora of North of Ireland	20	0	0
Exploration of Caves of South of Ireland	10	0	0
Fossil Plants of Halifax	15	0	0
Fundamental Invariants of Algebraical Forms	76	1	11
Record of Zoological Literature	100	0	0
British Polyzoa	10	0	0
Naples Zoological Station	80	0	0
Natural History of Timor-laut	100	0	0
Conversion of Sedimentary Materials into Metamorphic Rocks	10	0	0
Natural History of Socotra	100	0	0
Circulation of Underground Waters	15	0	0
Migration of Birds	15	0	0
Earthquake Phenomena of Japan	25	0	0

	£	s.	d.
Geological Map of Europe ...	25	0	0
Elimination of Nitrogen by Bodily Exercise...............	50	0	0
Anthropometric Committee...	50	0	0
Photographing Ultra-Violet Spark Spectra	25	0	0
Exploration of Raygill Fissure	20	0	0
Calibration of Mercurial Thermometers	20	0	0
Wave-length Tables of Spectra of Elements...............	50	0	0
Geological Record...............	100	0	0
Standards for Electrical Measurements	100	0	0
Exploration of Central Africa	100	0	0
Albuminoid Substances of Serum	10	0	0
	£1126	1	11

1883.

	£	s.	d.
Natural History of Timor-laut	50	0	0
British Fossil Polyzoa	10	0	0
Circulation of Underground Waters..........................	15	0	0
Zoological Literature Record	100	0	0
Exploration of Mount Kilima-njaro......................	500	0	0
Erosion of Sea-coast of England and Wales	10	0	0
Fossil Plants of Halifax	0	0	0
Elimination of Nitrogen by Bodily Exercise...............	38	3	3
Isomeric Naphthalene Derivatives............................	15	0	0
Zoological Station at Naples	80	0	0
Investigation of Loughton Camp	10	0	0
Earthquake Phenomena of Japan	50	0	0
Meteorological Observations on Ben Nevis	50	0	0
Fossil Phyllopoda of Palæozoic Rocks	25	0	0
Migration of Birds	20	0	0
Geological Record...............	50	0	0
Exploration of Caves in South of Ireland	10	0	0
Scottish Zoological Station ...	25	0	0
Screw Gauges......................	5	0	0
	£1083	3	3

1884.

	£	s.	d.
Zoological Literature Record	100	0	0
Fossil Polyzoa.......................	10	0	0
Exploration of Mount Kilima-njaro, East Africa	500	0	0
Anthropometric Committee...	10	0	0
Fossil Plants of Halifax	15	0	0
International Geological Map	20	0	0
Erratic Blocks of England ...	10	0	0
Natural History of Timor-laut	50	0	0
Coagulation of Blood...........	100	0	0
Naples Zoological Station ...	80	0	0
Bibliography of Groups of Invertebrata	50	0	0
Earthquake Phenomena of Japan	75	0	0
Fossil Phyllopoda of Palæozoic Rocks	15	0	0
Meteorological Observatory at Chepstow.........................	25	0	0
Migration of Birds...............	20	0	0
Collecting and Investigating Meteoric Dust..................	20	0	0
Circulation of Underground Waters..........................	5	0	0
Ultra-Violet Spark Spectra ...	8	4	0
Tidal Observations...............	10	0	0
Meteorological Observations on Ben Nevis	50	0	0
	£1173	4	0

1885.

	£	s.	d.
Zoological Literature Record.	100	0	0
Vapour Pressures, &c., of Salt Solutions	25	0	0
Physical Constants of Solutions.............................	20	0	0
Recent Polyzoa	10	0	0
Naples Zoological Station ...	100	0	0
Exploration of Mount Kilimanjaro	25	0	0
Fossil Plants of British Tertiary and Secondary Beds .	50	0	0
Calculating Tables in Theory of Numbers....................	100	0	0
Exploration of New Guinea...	200	0	0
Exploration of Mount Roraima	100	0	0
Meteorological Observations on Ben Nevis	50	0	0
Volcanic Phenomena of Vesuvius	25	0	0
Biological Stations on Coasts of United Kingdom	150	0	0
Meteoric Dust	70	0	0
Marine Biological Station at Granton	100	0	0
Fossil Phyllopoda of Palæozoic Rocks	25	0	0
Migration of Birds	30	0	0
Synoptic Chart of Indian Ocean	50	0	0
Circulation of Underground Waters..........................	10	0	0
Geological Record	50	0	0
Reduction of Tidal Observations.............................	10	0	0
Earthquake Phenomena of Japan	70	0	0
Raygill Fissure	15	0	0
	£1385	0	0

1886.	£	s.	d.
Zoological Literature Record.	100	0	0
Exploration of New Guinea...	150	0	0
Secretion of Urine..............	10	0	0
Researches in Food-Fishes and Invertebrata at St. Andrews	75	0	0
Electrical Standards...........	40	0	0
Volcanic Phenomena of Vesuvius	30	0	0
Naples Zoological Station......	50	0	0
Meteorological Observations on Ben Nevis	100	0	0
Prehistoric Race in Greek Islands	20	0	0
North-Western Tribes of Canada..............................	50	0	0
Fossil Plants of British Tertiary and Secondary Beds...	20	0	0
Regulation of Wages under Sliding Scales	10	0	0
Exploration of Caves in North Wales	25	0	0
Migration of Birds	30	0	0
Geological Record...............	100	0	0
Chemical Nomenclature	5	0	0
Fossil Phyllopoda of Palæozoic Rocks	15	0	0
Solar Radiation..................	9	10	6
Magnetic Observations.........	10	10	0
Tidal Observations	50	0	0
Marine Biological Station at Granton	75	0	0
Physical and Chemical Bearings of Electrolysis	20	0	0
	£995	0	6

1887.	£	s.	d.
Volcanic Phenomena of Japan (1886 grant)	50	0	0
Standards of Light (1886 grant)............................	20	0	0
Silent Discharge of Electricity	20	0	0
Exploration of Cae Gwyn Cave, North Wales	20	0	0
Investigation of Lymphatic System..........................	25	0	0
Granton Biological Station ...	75	0	0
Zoological Record	100	0	0
Flora of China	75	0	0
Nature of Solution	20	0	0
Influence of Silicon on Steel	30	0	0
Plymouth Biological Station	50	0	0
Naples Biological Station ...	100	0	0
Volcanic Phenomena of Vesuvius	20	0	0
Regulation of Wages	10	0	0
Microscopic Structure of the Rocks of Anglesey............	10	0	0
Ben Nevis Observatory.........	75	0	0
Prehistoric Race of Greek Islands...........................	20	0	0
Flora and Fauna of the Cameroons	75	0	0
Provincial Museum Reports	5	0	0
Harmonic Analysis of Tidal Observations	15	0	0
Coal Plants of Halifax.........	25	0	0
Exploration of the Eocene Beds of the Isle of Wight...	20	0	0
Magnetic Observations.........	26	2	0
'Manure' Gravels of Wexford	10	0	0
Electrolysis.......................	30	0	0
Fossil Phyllopoda	20	0	0
Racial Photographs, Egyptian	20	0	0
Standards of Light (1887 grant)	10	0	0
Migration of Birds	30	0	0
Volcanic Phenomena of Japan (1887 grant)	50	0	0
Electrical Standards	50	0	0
Bathy-hypsographical Map of British Isles	7	6	0
Absorption Spectra	40	0	0
Solar Radiation	18	10	0
Circulation of Underground Waters............................	5	0	0
Erratic Blocks	10	0	0
	£1186	18	0

1888.	£	s.	d.
Flora of Bahamas	100	0	0
Biological Station at Granton	50	0	0
Flora of China	75	0	0
Carboniferous Flora of Lancashire and West Yorkshire	25	0	0
Properties of Solutions	25	0	0
Isomeric Naphthalene Derivatives..............................	25	0	0
Influence of Silicon on Steel	20	0	0
Action of Light on Hydracids	20	0	0
Marine Laboratory, Plymouth	100	0	0
Naples Zoological Station ...	100	0	0
Development of Teleostei ...	15	0	0
Precious Metals in Circulation	20	0	0
Value of Monetary Standard	10	0	0
Volcanic Phenomena of Vesuvius	20	0	0
Prehistoric Race in Greek Islands...........................	20	0	0
Palæontographical Society ...	50	0	0
Zoology and Botany of West Indies	100	0	0
Development of Fishes—St. Andrews	50	0	0
Pliocene Fauna of St. Erth...	50	0	
Lymphatic System	25	0	0
Ben Nevis Observatory.........	150	0	0
North-Western Tribes of Canada	100	0	0
Silent Discharge of Electricity	9	11	10
Manure Gravels of Wexford...	10	0	0
Sea Beach near Bridlington...	20	0	0
Effect of Occupations on Physical Development............	25	0	0
Magnetic Observations.........	15	0	0

	£	s.	d.
Methods of Teaching Chemistry	10	0	0
Uniform Nomenclature in Mechanics	10	0	0
Geological Record	50	0	0
Migration of Birds	30	0	0
Depth of Frozen Soil in Polar Regions	5	0	0
Circulation of Underground Waters	5	0	0
Standards of Light	79	2	3
Electrical Standards	2	6	4
Peradeniya Botanical Station	50	0	0
Erosion of Sea Coasts	10	0	0
Electrolysis	30	0	0
	£1511	0	5

1889.

	£	s.	d.
Volcanic Phenomena of Japan	25	0	0
Geology and Geography of Atlas Range	100	0	0
Observations on Surface Water Temperature	30	0	0
Bath 'Baths Committee' for further Researches	100	0	0
Flora of China	25	0	0
Natural History of Friendly Islands	100	0	0
Physiology of Lymphatic System	25	0	0
Volcanic Phenomena of Vesuvius	20	0	0
Characteristics of Nomad Tribes of Asia Minor	30	0	0
Fossil Phyllopoda of Palæozoic Rocks	20	0	0
Investigation into North-Western Tribes of Canada	150	0	0
West Indian Explorations	100	0	0
Corresponding Societies	20	0	0
Experiments with a Tow-net	5	16	3
Geological Record	80	0	0
Marine Biological Association	200	0	0
Naples Zoological Station	100	0	0
Higher Eocene Beds of Isle of Wight	15	0	0
Ben Nevis Observatory	50	0	0
Methods of teaching Chemistry	10	0	0
Action of Light on Hydracids of the Halogen in presence of Oxygen	10	0	0
Electrical Standards	75	0	0
Action of Waves and Currents in Estuaries by means of Working Models	100	0	0
Electrolysis	20	0	0
Silent Discharge of Electricity on Oxygen	6	4	8
	£1417	0	11

General Meetings.

On Wednesday, September 11, at 8 P.M., in St. George's Drill Hall, Sir F. J. Bramwell, Bart., D.C.L., F.R.S., M.Inst.C.E., resigned the office of President to Professor W. H. Flower, C.B., LL.D., F.R.S., F.R.C.S., Pres.Z.S., F.L.S., F.G.S., Director of the Natural History Departments of the British Museum, who took the Chair, and delivered an Address, for which see page 1.

On Thursday, September 12, at 8 P.M., a Soirée took place in the Natural History Museum.

On Friday, September 13, at 8.30 P.M., in St. George's Drill Hall, Professor W. C. Roberts-Austen, F.R.S., F.C.S., delivered a discourse on 'The Hardening and Tempering of Steel.'

On Monday, September 16, at 8.30 P.M., in St. George's Drill Hall, Walter Gardiner, Esq., M.A., delivered a discourse on 'How Plants maintain themselves in the Struggle for Existence.'

On Tuesday, September 17, at 8 P.M., a Soirée took place in the Natural History Museum.

On Wednesday, September 18, at 2.30 P.M., in St. George's Drill Hall, the concluding General Meeting took place, when the Proceedings of the General Committee and the Grants of Money for Scientific Purposes were explained to the Members.

The Meeting was then adjourned to Leeds. [The Meeting is appointed to commence on Wednesday, September 3, 1890.]

PRESIDENT'S ADDRESS.

ADDRESS

BY

PROFESSOR W. H. FLOWER,

C.B., LL.D., F.R.S., F.R.C.S., Pres.Z.S., F.L.S., F.G.S.,

PRESIDENT.

It is twenty-six years since this Association met in Newcastle-upon-Tyne. It had then the advantage of being presided over by one of the most distinguished and popular of your fellow-townsmen.

Considering the age usually attained by those upon whom the honour of the presidency falls, and the length of time which elapses before the Association repeats its visit, it must have rarely happened that any one who has held the office is spared, not only to be present at another meeting in the town in which he has presided, but also to take such an active part in securing its success, and to extend such a hospitable welcome to his successor, as Lord Armstrong has done upon the present occasion.

The address which was delivered at that meeting must have been full of interest to the great majority of those present. It treated of many subjects more or less familiar and important to the dwellers in this part of the world, and it treated them with the hand of a master, a combination which always secures the attention of an audience.

When it came to my knowledge that in the selection of the President for this meeting the choice had fallen upon me, I was filled with apprehension. There was nothing in my previous occupations or studies from which I felt that I could evolve anything in special sympathy with what is universally recognised as the prevailing genius of this district. I was, however, somewhat reassured when reminded that in the regular rotation by which the equal representation in the presidential office of the different branches of science included in the Association is secured, the turn had come round for some one connected with biological subjects to occupy the chair, which during the past seven years has been filled with such distinction by engineers, chemists, physicists, mathematicians, and geologists.

I was also reminded that the Association, though of necessity holding its meeting in some definite locality, was by no means local in its character, but that its sphere was co-extensive, not with the United Kingdom only, but with the whole of the British Dominions, and that our proceedings are followed with interest wherever our language is understood—I may say, throughout the civilised world. Furthermore, although its great manufacturing industries, the eminence of its citizens for their skill and intelligence in the practical application of mechanical sciences, and the interesting and important geological features of its vicinity, have conferred such fame on Newcastle as almost to have overshadowed its other claims to distinction in connection with science, this neighbourhood is also associated with Bewick, with Johnson, with Alder, Embleton, Hutton, Atthey, Norman, the two Hancocks, the two Bradys, and other names honoured in the annals of biology; it has long maintained a school of medicine of great repute; and there has lately been established here a natural history museum which in some of its features is a model for institutions of the kind, and which, I trust, will be a means of encouraging in this town some of the objects the Association was designed to promote.

There can be no doubt that among the various methods by which the aims of the British Association (as expressed in its full title, the *advancement of science*) may be brought about, the collection and preservation of objects available for examination, study, and reference—in fact, the formation of what are now called 'museums'—is one of very great practical importance; so much so, indeed, that it seems to me one to the consideration of which it is desirable to devote some time upon such an occasion as this. It is a subject still little understood, though, fortunately, beginning to attract attention. It has already been brought before the notice of the Association, both in presidential and sectional addresses. A committee of our members is at the present time engaged in collecting evidence upon it, and has issued some valuable reports. During the present year an association of curators and others interested in museums has been founded for the purpose of interchange of ideas upon the organisation and management of these institutions. It is a subject, moreover, if I may be allowed to mention a personal reason for bringing it forward this evening, which has more than any other occupied my time and my attention almost from the earliest period of my recollection, and I think you will agree with the opinion of one of my distinguished predecessors in this chair, 'that the holder of this office will generally do better by giving utterance to what has already become part of his own thought than by gathering matter outside of its habitual range for the special occasion. For,' continued Mr. Spottiswoode, 'the interest (if any) of an address consists not so much in the multitude of things therein brought forward as in the individuality of the mode in which they are treated.'

The first recorded institution which bore the name of museum, or temple or haunt of the Muses, was that founded by Ptolemy Soter at Alexandria about 300 B.C.; but this was not a museum in our sense of the word, but rather, in accordance with its etymology, a place appropriated to the cultivation of learning, or which was frequented by a society or academy of learned men devoting themselves to philosophical studies and the improvement of knowledge.

Although certain great monarchs, as Solomon of Jerusalem and Augustus of Rome, displayed their taste and their magnificence by assembling together in their palaces curious objects brought from distant parts of the world—although it is said that the liberality of Philip and Alexander supplied Aristotle with abundant materials for his researches—of the existence of any permanent or public collections of natural objects among the ancients there is no record. Perhaps the nearest approach to such collections may be found in the preservation of remarkable specimens, sometimes associated with superstitious veneration, sometimes with strange legendary stories, in the buildings devoted to religious worship. The skins of the gorillas brought by the navigator Hanno from the West Coast of Africa, and hung up in the temple at Carthage, afford a well-known instance.

With the revival of learning in the Middle Ages, the collecting instinct, inborn in so many persons of various nations and periods of history, but so long in complete abeyance, sprang into existence with considerable vigour, and a museum, now meaning a collection of miscellaneous objects, antiquities as well as natural curiosities, often associated with a gallery of sculpture and painting, became a fashionable appendage to the establishment of many wealthy persons of superior culture.

All the earliest collections, comparable to what we call museums, were formed by and maintained at the expense of private individuals; sometimes physicians, whose studies naturally led them to a taste for biological science; often great merchant princes, whose trading connections afforded opportunities for bringing together things that were considered curious from foreign lands; or ruling monarchs in their private capacity. In every case they were maintained mainly for the gratification of the possessor or his personal friends, and rarely, if ever, associated with any systematic teaching or public benefit.

One of the earliest known printed catalogues of such a museum is that of Samuel Quickelberg, a physician of Amsterdam, published in 1565 in Munich. In the same year Conrad Gesner published a catalogue of the collection of Johann Kentmann, a physician of Torgau in Saxony, consisting of about 1,600 objects, chiefly minerals, shells, and marine animals. Very soon afterwards we find the Emperor Rudolph II. of Germany busily accumulating treasures which constituted the foundations of the present magnificent museums by which the Austrian capital is distinguished.

In England the earliest important collectors of miscellaneous objects

were the two John Tradescants, father and son, the latter of whom published, in 1656, a little work called 'Musæum Tradescantianum; or, a Collection of Rarities preserved at South Lambeth neer London.' The wonderful variety and incongruous juxtaposition of the objects contained in this collection make the catalogue very amusing reading. Under the first division, devoted to 'Some Kindes of Birds, their Egges, Beaks, Feathers, Clawes and Spurres,' we find 'Divers sorts of Egges from Turkie, one given for a Dragon's Egge'; 'Easter Egges of the Patriarch of Jerusalem'; 'Two Feathers of the Phœnix Tayle'; 'The Claw of the bird Rock, who, as Authors report, is able to trusse an Elephant.' Among 'whole birds' is the famous 'Dodar from the Island Mauritius; it is not able to flie, being so big.' This is the identical specimen, the head and foot of which has passed through the Ashmolean into the University Museum of Oxford; but we know not what has become of the claw of the Rock, the Phœnix tayle, and the Dragon's egg. Time does not allow me to mention the wonderful things which occur under the head of 'Garments, Vestures, Habits, and Ornaments,' or the 'Mechanick, Artificial Workes in Carvings, Turnings, Sowings, and Paintings,' from Edward the Confessor's knit gloves, and the famous 'Pohatan, King of Virginia's habit, all embroidered with shells or Roanoke,' also still at Oxford, and lately figured and described by Mr. E. B. Tylor, to the 'Cherry-stone, upon one side S. George and the Dragon, perfectly cut, and on the other side 88 Emperours' faces'; or the other 'cherry-stone, holding ten dozen of tortois-shell combs made by Edward Gibbons.' But before leaving these private collections I cannot forbear mentioning, as an example of the great aid they often were in advancing science, the indebtedness of Linnæus in his early studies to the valuable zoological museums, which it was one of the ruling passions of several kings and queens of Sweden to bring together.

Upon the association of individuals together into societies to promote the advancement of knowledge, these bodies in their corporate capacity frequently made the formation of a museum part of their function. The earliest instance of this in our country was the museum of the Royal Society in Crane Court, of which an illustrated catalogue was published by Dr. Grew in 1681.

The idea that the maintenance of a museum was a portion of the public duty of the State or of any municipal institution had, however, nowhere entered into the mind of man at the beginning of the last century. Even the great teaching bodies, the Universities, were slow in acquiring collections; but it must be recollected that the subjects considered most essential to the education they then professed to give were not those which needed illustration from the objects which can be brought together in a museum. The Italian Universities, where anatomy was taught as a science earlier and more thoroughly than anywhere else in Europe, soon found the desirability of keeping collections of preserved

specimens, and the art of preparing them attained a high degree of excellence at Padua and Bologna two centuries ago. But these were generally the private property of the professors, as were nearly all the collections used to illustrate the teaching of anatomy and pathology in our country within the memory of many now living.

Notwithstanding the multiplication of public museums during the present century, and the greater resources and advantages which many of these possess, which private collectors cannot command, the spirit of accumulation in individuals has happily not passed away, although usually directed into rather different channels than formerly. The general museums or miscellaneous collections of old are now left to governments and institutions which afford greater guarantee of their permanence and public utility, while admirable service is done to science by those private persons with leisure and means who, devoting themselves to some special subject, amass the materials by which its study can be pursued in detail either by themselves or by those they know to be qualified to do so; which collections, if they fulfil their most appropriate destiny, ultimately become incorporated, by gift or purchase, in one or other of the public museums, and then serve as permanent factors in the education of the nation, or rather of the world.

It would be passing beyond the limits of time allotted to this address, indeed going beyond the scope of the Association, if I were to speak of many of the subjects which have pre-eminently exercised the faculties of the collector and formed the materials of which museums are constructed. The various methods by which the mind of man has been able to reproduce the forms of natural objects or to give expression to the images created by his own fancy, from the rudest scratchings of a savage on a bone, or the simplest arrangement of lines employed in ornamenting the roughest piece of pottery, up to the most lovely combinations of form and colour hitherto attained in sculpture or in painting, or in works in metal or in clay, depend altogether on museums for their preservation, for our knowledge of their condition and history in the past, and for the lessons which they can convey for the future.

Apart from the delight which the contemplation of the noblest expressions of art must produce in all cultivated minds, apart also from the curiosity and interest that must be excited by all the less successfully executed attempts to produce similar results, as materials for constructing the true history of the life of man, at different stages of civilisation, in different circumstances of living, and in divers regions of the earth, such collections are absolutely invaluable.

But I must pass them by in order to dwell more in detail upon those which specially concern the advancement of the subjects which come under the notice of this Association—museums devoted to the so-called 'natural history' sciences, although much which will be said of them will doubtless be more or less applicable to museums in general.

The terms '*natural history*' and '*naturalist*' have become deeply rooted in our language, but without any very definite conception of their meaning or the scope of their application. Originally applied to the study of all the phenomena of the universe which are independent of the agency of man, natural history has gradually narrowed down in most people's minds, in consequence of the invention of convenient and generally understood and accepted terms for some of its various subdivisions, as astronomy, chemistry, geology, &c., into that portion of the subject which treats of the history of creatures endowed with life, for which, until lately, no special name had been invented. Even from this limitation botany was gradually disassociating itself in many quarters, and a 'naturalist' and a 'zoologist' have nearly become, however irrationally, synonymous terms. The happy introduction and general acceptance of the word 'biology,' notwithstanding the objections raised to its etymological signification, have reunited the study of organisms distinguished by the possession of the living principle, and practically eliminated the now vague and indefinite term 'natural history' from scientific terminology. As, however, it is certain to maintain its hold in popular language, I would venture to suggest the desirability of restoring it to its original and really definite signification, contrasting it with the history of man and of his works, and of the changes which have been wrought in the universe by his intervention.

It was in this sense that, when the rapid growth of the miscellaneous collections in the British Museum at Bloomsbury (the expansion of Sir Hans Sloane's accumulation in the old Manor House at Chelsea) was thought to render a division necessary, the line of severance was effected at the junction of what was natural and what was artificial; the former, including the products of what are commonly called 'natural' forces, unaffected by man's handiwork, or the impress of his mind. The departments which took cognisance of these were termed the 'Natural History Departments,' and the new building to which they were removed the 'Natural History Museum.'

It may be worth while to spend a few moments upon the consideration of the value of this division, as it is one which concerns the arrangement and administration of the majority of museums.

Though there is very much to be said for it, the objection has been raised that it cuts man himself in two. The illustrations of man's bodily structure are undoubtedly subjects for the zoologist. The subtile gradations of form, proportion, and colour which distinguish the different races of men, can only be appreciated by one with the education of an anatomist, and whose eye has been trained to estimate the value of such characters in discriminating the variations of animal forms. The subjects for comparison required for this branch of research must therefore be looked for in the zoological collections.

But the comparatively new science of 'anthropology' embraces not

only man's physical structure: it includes his mental development, his manners, customs, traditions, and languages. The illustrations of his works of art, domestic utensils, and weapons of war are essential parts of its study. In fact it is impossible to say where it ends. It includes all that man is or ever has been, all that he has ever done. No definite line can be drawn between the rudest flint weapon and the most exquisitely finished instrument of destruction which has ever been turned out from the manufactory at Elswick, between the rough representation of a mammoth, carved by one of its contemporary men on a portion of its own tusk, and the most admirable production of a Landseer. An anthropological collection, to be logical, must include all that is in not only the old British Museum but the South Kensington Museum and the National Gallery. The notion of an anthropology which considers savages and pre-historic people as apart from the rest of mankind may, in the limitations of human powers, have certain conveniences, but it is utterly unscientific and loses sight of the great value of the study in tracing the gradual growth of our complex systems and customs from the primitive ways of our progenitors.

On the other hand, the division first indicated is as perfectly definite, logical, and scientific as any such division can be. That there are many inconveniences attending wide local disjunctions of the collections containing subjects so distinct yet so nearly allied as physical and psychical anthropology must be fully admitted; but these could only have been overcome by embracing in one grand institution the various national collections illustrating the different branches of science and art, placed in such order and juxtaposition that their mutual relations might be apparent, and the resources of each might be brought to bear upon the elucidation of all the others—an ideal institution, such as the world has not yet seen, but into which the old British Museum might at one time have been developed.

A purely 'Natural History Museum' will then embrace a collection of objects illustrating the natural productions of the earth, and in its widest and truest sense should include, as far as they can be illustrated by museum specimens, all the sciences which deal with natural phenomena. It has only been the difficulties, real or imaginary, in illustrating them which have excluded such subjects as astronomy, physics, chemistry, and physiology from occupying departments in our National Natural History Museum, while allowing the introduction of their sister sciences, mineralogy, geology, botany, and zoology.

Though the experimental sciences and those which deal with the laws which govern the universe, rather than with the materials of which it is composed, have not hitherto greatly called forth the collector's instinct, or depended upon museums for their illustration, yet the great advantages of collections of the various instruments by means of which these sciences are pursued, and of examples of the methods by which they are taught, are

yearly becoming more manifest. Museums of scientific apparatus now form portions of every well-equipped educational establishment, and under the auspices of the Science and Art Department at South Kensington a national collection illustrating those branches of natural history science which have escaped recognition in the British Museum is assuming a magnitude and importance which brings the question of properly housing and displaying it urgently to the front.

Anomalies such as these are certain to occur in the present almost infantile though rapidly progressive state of science. It may be taken for granted that no scientific institution of any complexity of organisation can be, except at the moment of its birth, abreast of the most modern views of the subject, especially in the dividing lines between, and the proportional representation of, the various branches of knowledge which it includes.

The necessity for subdivisions in the study of science is continually becoming more apparent as the knowledge of the details of each subject multiplies without corresponding increase in the power of the human mind to grasp and deal with them, and the dividing lines not only become sharper, but as knowledge advances they frequently require revision. It might be supposed that such revision would adjust itself to the direction taken by the natural development of the relations of the different branches of science, and the truer conceptions entertained of such relations. But this is not always so. Artificial barriers are continually being raised to keep these dividing lines in the direction in which they have once started. Difficulties of readjustment arise not only from the mechanical obstacles caused by the size and arrangements of the buildings and facilities for the allocation of various kinds of collections, but still more from the numerous personal interests which grow up and wind their meshes around such institutions. Professorships and curatorships of this or that division of science are founded and endowed, and their holders are usually tenacious either of encroachment upon or of any wide enlargement of the boundaries of the subject they have undertaken to teach or to illustrate; and in this way, more than any other, passing phases of scientific knowledge have become crystallised or fossilised in institutions where they might least have been expected. I may instance many European universities and great museums in which zoology and comparative anatomy are still held to be distinct subjects taught by different professors, and where, in consequence of the division of the collections under their charge, the skin of an animal, illustrating its zoology, and its skeleton and teeth, illustrating its anatomy, must be looked for in different and perhaps remotely placed buildings.

For the perpetuation of the unfortunate separation of palæontology from biology, which is so clearly a survival of an ancient condition of scientific culture, and for the maintenance in its integrity of the heterogeneous compound of sciences which we now call 'geology,'

the faulty organisation of our museums is in a great measure responsible. The more their rearrangement can be made to overstep and break down the abrupt line of demarcation which is still almost universally drawn between beings which live now and those which have lived in past times, so deeply rooted in the popular mind and so hard to eradicate even from that of the scientific student, the better it will be for the progress of sound biological knowledge.

But it is not of the removal of such great anomalies and inconsistencies which, when they have once grown up, require heroic methods to set them right, but rather of certain minor defects in the organisation of almost all existing museums which are well within the capacity of comparatively modest administrative means to remedy, that I have now to speak.

That great improvements have been lately effected in many respects in some of the museums in this country, on the Continent, and especially in America, no one can deny. The subject, as I have already indicated, is, happily, exciting the attention of those who have the direction of them, and even awakening interest in the mind of the general public. It is in the hope of in some measure helping on or guiding this movement that I have ventured on the remarks which follow.

The first consideration in establishing a museum, large or small, either in a town, institution, society, or school, is that it should have some definite object or purpose to fulfil; and the next is that means should be forthcoming not only to establish but also to maintain the museum in a suitable manner to fulfil that purpose. Some persons are enthusiastic enough to think that a museum is in itself so good an object that they have only to provide a building and cases and a certain number of specimens, no matter exactly what, to fill them and then the thing is done; whereas the truth is the work has only then begun. What a museum really depends upon for its success and usefulness is not its building, not its cases, not even its specimens, but its curator. He and his staff are the life and soul of the institution, upon whom its whole value depends; and yet in many—I may say most of our museums—they are the last to be thought of. The care, the preservation, the naming of the specimens are either left to voluntary effort—excellent often for special collections and for a limited time, but never to be depended on as a permanent arrangement—or a grievously undersalaried and consequently uneducated official is expected to keep in order, to clean, dust, arrange, name, and display in a manner which will contribute to the advancement of scientific knowledge, collections ranging in extent over almost every branch of human learning, from the contents of an ancient British barrow to the last discovered bird of paradise from New Guinea.

Valuable specimens not unfrequently find their way into museums thus managed. Their public-spirited owners fondly imagine that they will be preserved and made of use to the world if once given to such an

institution. Their fate is, unfortunately, far otherwise. Dirty, neglected, without label, their identity lost, they are often finally devoured by insects or cleared away to make room on the crowded shelves for the new donation of some fresh patron of the institution. It would be far better that such museums should never be founded. They are traps into which precious—sometimes priceless—objects fall only to be destroyed; and, what is still worse, they bring discredit on all similar institutions, make the very name of museum a byword and a reproach, hindering instead of advancing the recognition of their value as agents in the great educational movement of the age.

A museum is like a living organism—it requires continual and tender care. It must grow, or it will perish; and the cost and labour required to maintain it in a state of vitality is not yet by any means fully realised or provided for, either in our great national establishments or in our smaller local institutions.

Often as it has been said, it cannot be too often repeated, that the real objects of forming collections, of whatever kind (apart, of course, from the mere pleasure of acquisition—sometimes the only motive of private collectors), and which, although in very different degrees, and often without being recognised, underlie the organisation of all museums, are two, which are quite distinct, and sometimes even conflicting. The first is to advance or increase the knowledge of some given subject. This is generally the motive of the individual collector, whose experience shows him the vast assistance in forming definite ideas in any line of research in which he may be occupied that may be derived from having the materials for its study at his own command, to hold and to handle, to examine and compare, to take up and lay aside whenever the favourable moment to do so occurs. But unless his subject is a very limited one, or his means the reverse, he soon finds the necessity of consulting collections based on a larger scale than his own. Very few people have any idea of the multiplicity of specimens required for the purpose of working out many of the simplest problems concerning the life-history of animals or plants. The naturalist has frequently to ransack all the museums, both public and private, of Europe and America in the endeavour to compose a monograph of a single common genus, or even species, that shall include all questions of its variation, changes in different seasons, and under different climates and conditions of existence, and the distribution in space and time of all its modifications. He often has to confess at the end that he has been baffled in his research for want of the requisite materials for such an undertaking. Of course this ought not to be, and the time will come when it will not be, but that time is very far off yet.

We all know the old saying that the craving for riches grows as the wealth itself increases. Something similar is true of scientific collections brought together for the purpose of advancing knowledge. The larger they are the more their deficiencies seem to become conspicuous; the

more desirous we are to fill up the gaps which provokingly interfere with our extracting from them the complete story they have to tell.

Such collections are, however, only for the advanced student, the man who has already become acquainted with the elements of his science and is in a position, by his knowledge, by his training, and by his observing and reasoning capacity, to take advantage of such material to carry on the subject to a point beyond that at which he takes it up.

But there is another and a far larger class to whom museums are or should be a powerful means of aid in acquiring knowledge. Among such those who are commencing more serious studies may be included; but I especially refer to the much more numerous class, and one which it may be hoped will year by year bear a greater relative proportion to the general population of the country, who, without having the time, the opportunities, or the abilities to make a profound study of any branch of science, yet take a general interest in its progress, and wish to possess some knowledge of the world around them and of the principal facts ascertained with regard to it, or at least some portions of it. For such persons museums may be, when well organised and arranged, of benefit to a degree that at present can scarcely be realised.

To diffuse knowledge among persons of this class is the second of the two purposes of museums of which I have spoken.

I believe that the main cause of what may be fairly termed the failure of the majority of museums—especially museums of natural history—to perform the functions that might be legitimately expected of them is that they nearly always confound together the two distinct objects which they may fulfil, and by attempting to combine both in the same exhibition practically accomplish neither.

In accordance with which of those two objects, which may be briefly called *research* and *instruction*, is the main end of the museum, so should the whole be primarily arranged; and in accordance with the object for which each specimen is required, so should it be treated.

The specimens kept for research, for advancement of knowledge, for careful investigations in structure and development, or for showing the minute distinctions which must be studied in working out the problems connected with variations of species according to age, sex, season, or locality; for fixing the limits of geographical distribution, or determining the range in geological time, must be not only exceedingly numerous (so numerous, indeed, that it is almost impossible to put a limit on what may be required for such purposes), but they must also be kept under such conditions as to admit of ready and close examination and comparison.

If the whole of the specimens really required for enlarging the boundaries of zoological or botanical science were to be displayed in such a manner that each one could be distinctly seen by any visitor sauntering through the public galleries of a museum, the vastness and expense of the

institution would be out of all proportion to its utility; the specimens themselves would be quite inaccessible to the examination of all those capable of deriving instruction from them, and, owing to the injurious effects of continued exposure to light upon the greater number of preserved natural objects, would ultimately lose a large part of their permanent value. Collections of this kind must, in fact, be treated as the books in a library, and be used only for consultation and reference by those who are able to read and appreciate their contents. To demand, as has been ignorantly done, that all the specimens belonging to our national museums, for instance, should be displayed in cases in the public galleries, would be equivalent to asking that every book in a library, instead of being shut up and arranged on shelves for consultation when required, should have every single page framed and glazed and hung on the walls, so that the humblest visitor as he passes along the galleries has only to open his eyes and revel in the wealth of literature of all ages and all countries, without so much as applying to a custodian to open a case. Such an arrangement is perfectly conceivable. The idea from some points of view is magnificent, almost sublime. But imagine the space required for such an arrangement of the national library of books, or, indeed, of any of the smallest local libraries; imagine the inconvenience to the real student, the disadvantages which he would be under in reading the pages of any work fixed in an immovable position beneath a glass case; think of the enormous distances he would often have to traverse to compare a reference or verify a quotation, and the idea of sublimity soon gives place to its usual antithesis. The attempt to display every bird, every insect, shell, or plant which is or ought to be in any of our great museums of reference would produce an exactly similar result.

In the arrangement of collections designed for research, which, of course, will contain all those precious specimens called 'types,' which must be appealed to through all time to determine the species to which a name was originally given, the principal points to be aimed at are—the preservation of the objects from all influences deleterious to them, especially dust, light, and damp; their absolutely correct identification, and record of every circumstance that need be known of their history; their classification and storage in such a manner that each one can be found without difficulty or loss of time; and, both on account of expense as well as convenience of access, they should be made to occupy as small a space as is compatible with these requirements. They should be kept in rooms provided with suitable tables and good light for their examination, and within reach of the necessary books of reference on the particular subjects which the specimens illustrate. Furthermore, the rooms should be so situated that the officers of the museum, without too great hindrance to their own work, can be at hand for occasional assistance and supervision of the student, and if collections of research and exhibited specimens are contained in one building, it is obvious that the closer the contiguity

in which those of any particular group are placed the greater will be the convenience both of students and curators, for in very few establishments will it be possible to form each series on such a scale as to be entirely independent of the other.

On the other hand, in a collection arranged for the instruction of the general visitor, the conditions under which the specimens are kept should be totally different. In the first place, their numbers must be strictly limited, according to the nature of the subject to be illustrated and the space available. None must be placed too high or too low for ready examination. There must be no crowding of specimens one behind the other, every one being perfectly and distinctly seen, and with a clear space around it. Imagine a picture-gallery with half the pictures on the walls partially or entirely concealed by others hung in front of them; the idea seems preposterous, and yet this is the approved arrangement of specimens in most public museums. If an object is worth putting into a gallery at all it is worth such a position as will enable it to be seen. Every specimen exhibited should be good of its kind, and all available skill and care should be spent upon its preservation and rendering it capable of teaching the lesson it is intended to convey. And here I cannot refrain from saying a word upon the sadly neglected art of taxidermy, which continues to fill the cases of most of our museums with wretched and repulsive caricatures of mammals and birds, out of all natural proportions, shrunken here and bloated there, and in attitudes absolutely impossible for the creature to have assumed while alive. Happily there may be seen occasionally, especially where amateurs of artistic taste and good knowledge of natural history have devoted themselves to the subject, examples enough—and you are fortunate in possessing them in Newcastle—to show that an animal can be converted after death, by a proper application of taxidermy, into a real life-like representation of the original, perfect in form, proportions, and attitude, and almost, if not quite, as valuable for conveying information on these points as the living creature itself. The fact is that taxidermy is an art resembling that of the painter or rather the sculptor; it requires natural genius as well as great cultivation, and it can never be permanently improved until we have abandoned the present conventional low standard and low payment for 'bird-stuffing,' which is utterly inadequate to induce any man of capacity to devote himself to it as a profession.

To return from this digression, every specimen exhibited should have its definite purpose, and no absolute duplicate should on any account be permitted. Above all, the purpose for which each specimen is exhibited, and the main lesson to be derived from it, must be distinctly indicated by the labels affixed, both as headings of the various divisions of the series, and to the individual specimens. A well-arranged educational museum has been defined as a collection of instructive labels illustrated by well-selected specimens.

What is, or should be, the order of events in arranging a portion of a public museum? Not, certainly, as too often happens now, bringing a number of specimens together almost by haphazard, and cramming them as closely as possible in a case far too small to hold them, and with little reference to their order or to the possibility of their being distinctly seen. First, as I said before, you must have your curator. He must carefully consider the object of the museum, the class and capacities of the persons for whose instruction it is founded, and the space available to carry out this object. He will then divide the subject to be illustrated into groups, and consider their relative proportions, according to which he will plan out the space. Large labels will next be prepared for the principal headings, as the chapters of a book, and smaller ones for the various subdivisions. Certain propositions to be illustrated, either in the structure, classification, geographical distribution, geological position, habits, or evolution of the subjects dealt with, will be laid down and reduced to definite and concise language. Lastly will come the illustrative specimens, each of which as procured and prepared will fall into its appropriate place. As it is not always easy to obtain these at the time that they are wanted, gaps will often have to be left, but these, if properly utilised by drawings or labels, may be made nearly as useful as if occupied by the actual specimens.

A public exhibition which is intended to be instructive and interesting must never be crowded. There is, indeed, no reason why it ever should be. Every such exhibition, whether on a large or small scale, can only contain a representative series of specimens, selected with a view to the needs of the particular class of persons who are likely to visit the gallery, and the number of specimens exhibited should be adapted to the space available. There is, therefore, rarely any excuse for filling it up in such a manner as to interfere with the full view of every specimen shown. A crowded gallery, except in some very exceptional circumstances, at once condemns the curator, as the remedy is generally in his own hands. In order to avoid it he has nothing to do but sternly to eliminate all the less important specimens. If any of these possess features of historical or scientific interest demanding their permanent preservation, they should be kept in the reserve collections; if otherwise, they should not be kept at all.

The ideal public museums of the future will, however, require far more exhibition space than has hitherto been allowed; for though the number of specimens shown may be fewer than is often thought necessary now, each will require more room if the conditions above described are carried out, and especially if it is thought desirable to show it in such a manner as to enable the visitor to realise something of the wonderful complexity of the adaptations which bring each species into harmonious relation with its surrounding conditions. Artistic reproductions of natural environments, illustrations of protective resemblances, or of special modes

of life, all require much room for their display. This method of exhibition, wherever faithfully carried out, is, however, proving both instructive and attractive, and will doubtless be greatly extended.

Guide-books and catalogues are useful adjuncts, as being adapted to convey fuller information than labels, and as they can be taken away for study during the intervals of visits to the museum, but they can never supersede the use of labels. Anyone who is in the habit of visiting picture-galleries where the names of the artists and the subject are affixed to the frame, and others in which the information has in each case to be sought by reference to a catalogue, must appreciate the vast superiority in comfort and time-saving of the former plan.

Acting upon such principles as these, every public gallery of a museum, whether the splendid saloon of a national institution or the humble room containing the local collection of a village club, can be made a centre of instruction, and will offer interests and attractions which will be looked for in vain in the majority of such institutions at the present time.

One of the best illustrations of the different treatment of collections intended for research or advancement of knowledge, and for popular instruction or diffusion of knowledge, is now to be seen in Kew Gardens, where the admirably constructed and arranged herbarium answers the first purpose, and the public museums of economic botany the second. A similar distinction is carried out in the collections of systematic botany in the natural history branch of the British Museum, with the additional advantage of close contiguity; indeed, as an example of a scheme of good museum arrangement (although not perfect yet in details) I cannot do better than refer to the upper story of the east wing of that institution. The same principles, little regarded in former times in this country, and still unknown in some of the largest Continental museums, are gradually pervading every department of the institution, which, from its national character, its metropolitan position, and exceptional resources, ought to illustrate in perfection the ideal of a natural history museum. In fact, it is only in a national institution that an exhaustive research collection in all branches of natural history, in which the specialist of every group can find his own subject fully illustrated, can or ought to be attempted.

As the actual comparison of specimen with specimen is the basis of zoological and botanical research, and as work done with imperfect materials is necessarily imperfect in itself, it is far the wisest policy to concentrate in a few great central institutions, the number and situation of which must be determined by the population and the resources of the country, all the collections, especially those containing specimens already alluded to as so dear to the systematic naturalist, known as author's 'types,' required for original investigations. It is far more advantageous to the investigator to go to such a collection and take up his temporary

abode there, while his research is being carried out, with all the material required at his hand at once, than to travel from place to place and pick up piecemeal the information he requires, without opportunity of direct comparison of specimens.

I do not say that collections for special study, and even original research, should not, under particular circumstances and limitations, be formed at museums other than central national institutions, or that nothing should be retained in provincial museums but what is of a directly educational or elementary nature. A local collection, illustrating the fauna and flora of the district, should be part of every such museum; and this may be carried to almost any amount of detail, and therefore in many cases it would be very unadvisable to exhibit the whole of it. A selection of the most important objects may be shown under the conditions described above, and the remainder carefully preserved in cabinets for the study of specialists.

It is also very desirable in all museums, in order that the exhibited series should be as little disturbed as possible in arrangement, and be always available for the purpose for which it is intended, that there should be, for the use of teachers and students, a supplementary set of common objects, which, if injured, could be easily replaced. It must not be forgotten that the zealous investigator and the conscientious curator are often the direst antagonists: the one endeavours to get all the knowledge he can out of a specimen, regardless of its ultimate fate, and even if his own eyes alone have the advantage of it; the other is content if a limited portion only is seen, provided that can be seen by everyone both now and hereafter.

Such, then, is the primary principle which ought to underlie the arrangement of all museums—the distinct separation of the two objects for which collections are made; the publicly exhibited collection being never a store-room or magazine, but only such as the ordinary visitor can understand and profit by, and the collection for students being so arranged as to afford every facility for examination and research. The improvements that can be made in detail in both departments are endless, and to enter further into their consideration would lead me far beyond the limits of this address. Happily, as I said before, the subject is receiving much attention.

I would willingly dwell longer upon it—indeed I feel that I have only been able to touch slightly and superficially upon many questions of practical interest, well worthy of more detailed consideration—but time warns me that I must be bringing this discourse to a close, and I have still said nothing in reference to subjects upon which you may expect some words on this occasion. I mean those great problems concerning the laws which regulate the evolution of organic beings, problems which agitate the minds of all biologists of the present day, and the solution of which is watched with keen interest by a far wider circle—a circle, in

fact, coincident with the intelligence and education of the world. Several communications connected with these problems will be brought before the sectional meetings during the next few days, and we shall have the advantage of hearing them discussed by some of those who by virtue of their special attention to and full knowledge of these subjects are most competent to speak with authority. It is therefore for me rather delicate ground to tread upon, especially at the close of a discourse mainly devoted to another question. I will, however, briefly point out the nature of the problems and the lines which the endeavour to solve them will probably take, without attempting to anticipate the details which you will doubtless hear most fully and ably stated elsewhere.

I think I may safely premise that few, if any, original workers at any branch of biology appear now to entertain serious doubt about the general truth of the doctrine that all existing forms of life have been derived from other forms by a natural process of descent with modification, and it is generally acknowledged that to the records of the past history of life upon the earth we must look for the actual confirmation of the truth of a doctrine which accords so strongly with all we know of the present history of living beings.

Professor Huxley wrote in 1875: 'The only perfectly safe foundation for the doctrine of evolution lies in the historical, or rather archæological, evidence that particular organisms have arisen by the gradual modification of their predecessors, which is furnished by fossil remains. That evidence is daily increasing in amount and in weight, and it is to be hoped that the comparisons of the actual pedigree of these organisms with the phenomena of their development may furnish some criterion by which the validity of phylogenic conclusions deduced from the facts of embryology alone may be satisfactorily tested.'

Palæontology, however, as we all know, reveals her secrets with no open hand. How can we be reminded of this more forcibly than by the discovery announced scarcely three months ago by Professor Marsh of numerous mammalian remains from formations of the Cretaceous period, the absence of which had so long been a source of difficulty to all zoologists? What vistas does this discovery open of future possibilities, and what thorough discredit, if any were needed, does it throw on the value of negative evidence in such matters! Bearing fully in mind the necessary imperfection of the record we have to deal with, I think that no one taking an impartial survey of the recent progress of palæontological discovery can doubt that the evidence in favour of a gradual modification of living forms is still steadily increasing. Any regular progressive series of changes of structure coinciding with changes in time can of course only be expected to be preserved and to come again before our eyes under such a favourable combination of circumstances as must be of most rare occurrence; but the links, more or less perfect, of many such series are continually being revealed, and the discovery of a single inter-

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mediate form is often of immense interest as indicating the path along which the modification from one apparently distinct form to another may have taken place.

Though palæontology may be appealed to in support of the conclusion that modifications have taken place as time advanced, it can scarcely afford any help in solving the more difficult problems which still remain as to the methods by which the changes have been brought about.

Ever since the publication of what has been truly described as the 'creation of modern natural history,' Darwin's work on the 'Origin of Species,' there has been no little controversy as to how far all the modifications of living forms can be accounted for by the principle of natural selection or preservation of variations best adapted for their surrounding conditions, or whether any, and if so what, other factors have taken part in the process of organic evolution.

It certainly cannot be said that in these later times the controversy has ended. Indeed those who are acquainted with scientific literature must know that notes struck at the last annual meeting of this Association produced a series of reverberations, the echoes of which have hardly yet died away.

Within the last few months also two important works have appeared in our country, which have placed in an accessible and popular form many of the data upon which the most prevalent views on the subject are based.

The first is 'Darwinism: an Exposition of the Theory of Natural Selection, with some of its Applications,' by Alfred Russel Wallace. No one could be found so competent to give such an exposition of the theory as one who was, simultaneously with Darwin, its independent originator, but who, by the title he has chosen no less than by the contents of the book, has, with rare modesty and self-abnegation, transferred to his fellow-labourer all the merit of the discovery of what he evidently looks upon as a principle of overwhelming importance in the economy of nature; 'supreme,' indeed, he says, 'to an extent which even Darwin himself hesitated to claim for it.'

The other work I refer to is the English translation of the remarkable 'Essays upon Heredity and Kindred Biological Problems,' by Dr. August Weismann, published at the Oxford Clarendon Press, in which is fully discussed the very important but still open question—a question which was brought into prominence at our meeting at Manchester two years ago—of the transmission or non-transmission to the offspring of characters acquired during the lifetime of the parent.

It is generally recognised that it is one of the main elements of Darwin's, as well as of every other theory of evolution, that there is in every individual organic being an innate tendency to vary from the standard of its predecessors, but that this tendency is usually kept under the sternest control by the opposite tendency to resemble them, a force to which the terms 'heredity' and 'atavism' are applied. The causes

of this initial tendency to vary, as well as those of its limits and prevailing direction, and the circumstances which favour its occasional bursting through the constraining principle of heredity offer an endless field for speculation. Though several theories of variation have been suggested, I think that no one would venture to say we have passed beyond the threshold of knowledge of the subject at present.

Taking for granted, however, as we all do, that this tendency to individual variation exists, then comes the question, What are the agents by which, when it has asserted itself, it is controlled or directed in such a manner as to produce the permanent or apparently permanent modifications of organic structures which we see around us? Is 'survival of the fittest' or preservation by natural selection of those variations best adapted for their surrounding conditions (the essentially Darwinian or still more essentially Wallacian doctrine) the sole or even the chief of these agents? Can isolation, or the revived Lamarckian view of the direct action of the environment, or the effects of use or disuse accumulating through generations, either singly or combined, account for all? or is it necessary to invoke the aid of any of the numerous subsidiary methods of selection which have been suggested as factors in bringing about the great result?

Anyone who has closely followed these discussions, especially those bearing most directly upon what is generally regarded as the most important factor of evolution—natural selection, or 'survival of the fittest'—cannot fail to have noticed the appeal constantly made to the advantage, the utility, or otherwise of special organs or modifications of organs or structures to their possessors. Those who have convinced themselves of the universal application of the doctrine of natural selection hold that every particular structure or modification of structure must be of utility to the animal or plant in which it occurs, or to some ancestor of that animal or plant, otherwise it could not have come into existence; the only reservation being for cases which are explained by the principle which Darwin called 'correlation of growth.' Thus the extreme natural selectionists and the old-fashioned school of teleologists are so far in agreement.

On the other hand, it is held by some that numerous structures and modifications of structures are met with in nature which are manifestly useless; it is even confidently stated that there are many which are positively injurious to their possessor, and therefore could not possibly have resulted from the action of natural selection of favourable variations. Organs or modifications when in an incipient condition are especially quoted as bearing upon this difficulty. But here, it seems to me, we are continually appealing to a criterion by which to test our theories of which we know far too little, and this (though often relied upon as the strongest) is, in reality, the weakest point of the whole discussion.

Of the variations of the form and structure of organic bodies we are

beginning to know something. Our museums, when more complete and better organised, will teach us much on this branch of the subject. They will show us the infinite and wonderful and apparently capricious modifications of form, colour, and of texture to which every most minute portion of the organisation of the innumerable creatures which people the earth is subject. They will show us examples of marvellously complicated and delicate arrangements of organs and tissues in many of what we consider as almost the lowest and most imperfectly organised groups of beings with which we are acquainted. But as to the use of all these structures and modifications in the economy of the creatures that possess them, we know, I may almost say, nothing, and our museums will never teach us these things. If time permitted I might give numerous examples in the most familiar of all animals, whose habits and actions are matters of daily observation, with whose life-history we are as well acquainted almost as we are with our own, of structures the purposes of which are still most doubtful. There are many such even in the composition of our own bodies. How, then, can we expect to answer such questions when they relate to animals known to us only by dead specimens, or by the most transient glimpses of the living in a state of nature, or when kept under the most unnatural conditions in confinement? And yet this is actually the state of our knowledge of the vast majority of the myriads of living beings which inhabit the earth. How can we, with our limited powers of observation and limited capacity of imagination, venture to pronounce an opinion as to the fitness or unfitness for its complex surroundings of some peculiar modification of structure found in some strange animal dredged up from the abysses of the ocean, or which passes its life in the dim seclusion of some tropical forest, and into the essential conditions of whose existence we have at present no possible means of putting ourselves in any sort of relation?

How true it is that, as Sir John Lubbock says, 'we find in animals complex organs of sense richly supplied with nerves, but the functions of which we are as yet powerless to explain. There may be fifty other senses as different from ours as sound is from sight; and even within the boundaries of our own senses there may be endless sounds which we cannot hear, and colours as different as red from green of which we have no conception. These and a thousand other questions remain for solution. The familiar world which surrounds us may be a totally different place to other animals. To them it may be full of music which we cannot hear, of colour which we cannot see, of sensations which we cannot conceive.'

The fact is that nearly all attempts to assign purposes to the varied structures of animals are the merest guesses. The writers on natural history of the early part of the present century, who 'for every why must have a wherefore,' abound in these guesses, which wider knowledge shows to be untenable. Many of the arguments for or against natural selection, based upon the assumed utility or equally assumed

uselessness of animal and vegetable structures, have nothing more to recommend them. In fact, to say that any part of the organisation of an animal or plant, or any habit or instinct with which it is endowed, is useless, or, still more, injurious, seems to me an assumption which, in our present state of knowledge, we are not warranted in making. The time may come when we shall have more light, but infinite patience and infinite labour are required before we shall be in a position to speak dogmatically on these mysteries of nature—labour not only in museums, laboratories, and dissecting-rooms, but in the homes and haunts of the animals themselves, watching and noting their ways amid their natural surroundings, by which means alone we can hope to unravel the secrets of their life-history. But until that time comes, though we may not be quite tempted to echo the despairing cry of the poet, 'Behold, we know not anything,' a frank confession of ignorance is the best that we have to offer when questioned upon these subjects.

However much we may be convinced of the supreme value of scientific methods of observation and of reasoning, both as mental training of the individual and in the elucidation of truth and advancement of knowledge generally, it is impossible to be blind to the fact that we who are engaged with the investigation of those subjects which are commonly accepted as belonging to the domain of physical science are unfortunately not always, by virtue of being so occupied, possessed of that most precious gift, 'a right judgment in all things.'

No one intimately acquainted with the laborious and wavering steps of the progress of biological science can look upon that progress with a perfect feeling of satisfaction.

Can it be said of any of us that our observations are always accurate, the materials on which they are based always sufficient, our reasoning always sound, our conclusions always legitimate? Is there any subject, however limited, of which our knowledge can be said to have reached finality?

Or if it happens to any of us as to

> A man who looks at glass
> On it may stay his eye,
> Or if he pleases through it pass
> And then the heavens espy,

are not those heavens which are beyond the immediate objects of our observation coloured by our prejudices, prepossessions, emotions, or imagination, as often as they are defined by any profound insight into the depth of nature's laws? In most of these questions an open mind and a suspended judgment appear to me the true scientific position, whichever way our inclinations may lead us.

For myself, I must own that when I endeavour to look beyond the glass, and frame some idea of the plan upon which all the diversity in the organic world has been brought about, I see the strongest grounds for

the belief, difficult as it sometimes is in the face of the strange, incomprehensible, apparent defects in structure, and the far stranger, weird, ruthless savagery of habit, often brought to light by the study of the ways of living creatures, that natural selection, or survival of the fittest, has, among other agencies, played a most important part in the production of the present condition of the organic world, and that it is a universally acting and beneficent force continually tending towards the perfection of the individual, of the race, and of all living nature.

I can even go further and allow my dream still thus to run:

Oh yet we trust that somehow good
  Will be the final goal of ill,—

That nothing walks with aimless feet,
  That not one life shall be destroyed
  Or cast as rubbish to the void
When God hath made the pile complete.

REPORTS

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STATE OF SCIENCE.

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Fifth Report of the Committee, consisting of Professors A. Johnson (*Secretary*), J. G. Macgregor, J. B. Cherriman, *and* H. T. Bovey *and* Mr. C. Carpmael, *appointed for the purpose of promoting Tidal Observations in Canada.*

The Committee desire to refer to a previous report, in which it was announced that the then Minister of Marine (the Hon. G. Foster) had directed that some preliminary investigations should be made by Lieut. Gordon, R.N., who was to put himself in communication with Prof. Darwin. The Minister, however, said that the existing expenditure on hydrographic surveys made it necessary to postpone for the time the consideration of further steps concerning tidal observations.

Your Committee was reappointed last year to keep the subject before the notice of the Government, in the hope that this systematic tidal work would be begun this year. In May last an interview was obtained with the Hon. C. Tupper, the present Minister of Marine, at which Sir Wm. Dawson was present. The Minister expressed himself as entirely favourable to the institution of the proposed tidal observations, but said that the financial position as regards the expenditure on hydrographic surveys was the same as last year, and that therefore no further steps could be taken as yet in the matter.

It is believed that since the interview some of the expenditure in hydrographic surveys has ceased, and as there is reason to believe that other Cabinet ministers are in favour of the proposed measure, the Committee deem the prospects of carrying it into execution very satisfactory.

There is no doubt about the anxiety of shipmasters to have the tidal investigations set on foot immediately, and the Royal Society of Canada deem the matter of such great practical importance, that at their last meeting they appointed a special Committee to give energetic support to the action of this Committee.

First Report of the Committee, consisting of Lord RAYLEIGH (*Chairman*), Professor CAYLEY, Mr. J. W. L. GLAISHER, Professor A. G. GREENHILL, Professor W. M. HICKS, Professor B. PRICE, Sir WILLIAM THOMSON, *and* Professor A. LODGE (*Secretary*), *appointed for the purpose of considering the possibility of calculating Tables of certain Mathematical Functions, and, if necessary, of taking steps to carry out the calculations and to publish the results in an accessible form.*

THE tables which have first come under the consideration of the Committee are those of the Bessel Functions, viz., the solutions of the differential equations:

$$x^2\frac{d^2u}{dx^2}+x\frac{du}{dx}+(x^2-n^2)u=0 \quad . \quad . \quad . \quad (1),$$

and

$$x^2\frac{d^2u}{dx^2}+x\frac{du}{dx}+(x^2+n^2)u=0 \quad . \quad . \quad . \quad (2).$$

The two solutions of equation (1) are denoted by $J_n(x)$ and $Y_n(x)$. No tables appear to have been made of $Y_n(x)$, but there are several tables of $J_n(x)$. The most complete tables of $J_0(x)$ and $J_1(x)$, and the only tables of these functions which are published separately, have been published (at Berlin) during the present year by Dr. Meissel, of Kiel, giving the functions to 12 decimal places for values of x from 0 to 15·50 at intervals of 0·01. A short table is given by Bessel ('Über die planetarischen Störungen'), and others are to be found in Lommel, 'Über die Bessel'schen Functionen,' and Lord Rayleigh, 'Theory of Sound,' vol. i. Lommel's and Lord Rayleigh's tables were originally calculated by Hansen, and published by him, but the notation adopted by Hansen was different from that now used. What is usually called $J_n(x)$ he denoted by $J_n(\frac{1}{2}x)$. Lommel's tables give $J_0(x)$ and $J_1(x)$ to 6 places from $x=0$ to 20·0 at intervals of 0·1, and a few values of $J_n(x)$ for other integral values of n.

The two solutions of equation (2) the Committee propose to call $I_n(x)$ and $K_n(x)$, in accordance with that adopted by Mr. Basset in the second volume of his treatise on Hydromechanics. They have calculated $I_n(x)$ for integral values of n from 0 to 11, from $x=0$ to 6 0 at intervals of 0·2. The calculations are to 12 significant figures, except in the case of $I_{11}(x)$, some of which are given to 12 and some to 11 figures. The last figure is approximate. A series of n zeros between the decimal point and the first significant figure is expressed by 0^n. It is proposed to interpolate to the interval 0·01 in, at any rate, the cases of $I_0(x)$ and $I_1(x)$, and to continue them to higher values of x, with a view to publishing the various series of functions in book form.

The Committee desire to thank Professor M'Leod for the temporary loan of his 'Edmondson's Calculating Machine,' and Mr. Walter G. Gregory and Miss E. C. Lodge for considerable assistance in the calculations.

x	$I_0(x)$	$I_1(x)$	$I_2(x)$
0·0	1·00000000000	nil	nil
0·2	1·01002502780	·100500834028	·0²501668751391
0·4	1·04040178223	·204026755734	·0202680035615
0·6	1·09204536432	·313704025606	·0463652789678
0·8	1·16651492287	·432864802620	·0843529163180
1·0	1·26606587775	·565159103990	·135747669767
1·2	1·39372558413	·714677941552	·202595681546
1·4	1·55339509973	·886091981415	·287549411997
1·6	1·74998063974	1·08481063513	·393967345826
1·8	1·98955935662	1·31716723040	·526040211741
2·0	2·27958530233	1·59063685463	·688948447698
2·2	2·62914286357	1·91409465059	·889056817580
2·4	3·04925665799	2·29812381254	1·13415348087
2·6	3·55326890424	2·75538434051	1·43374248847
2·8	4·15729770350	3·30105582264	1·79940068733
3·0	4·88079258586	3·95337021738	2·24521244092
3·2	5·74720718718	4·73425389471	2·78829850299
3·4	6·78481316043	5·67010219264	3·44945892947
3·6	8·02768454705	6·79271460136	4·25395421296
3·8	9·51688802610	8·14042457894	5·23245403722
4·0	11·3019219521	9·75946515371	6·42218937528
4·2	13·4424561633	11·7056201430	7·86835133327
4·4	16·0104355250	14·0462213375	9·62578946244
4·6	19·0926234795	16·8625647618	11·7610735829
4·8	22·7936779931	20·2528346003	14·3549969097
5·0	27·2398718236	24·3356421424	17·5056149666
5·2	32·5835927106	29·2543098818	21·3319350638
5·4	39·0087877856	35·1820585061	25·9783957463
5·6	46·7375512926	42·3282880326	31·6203055668
5·8	56·0380968926	50·9461849787	38·4704468999
6·0	67·2344069764	61·3419367775	46·7870947172

x	$I_3(x)$	$I_4(x)$	$I_5(x)$
0·0	nil	nil	nil
0·2	·0^{3}167083750232	·0^{5}417500694777	·0^{7}834723214702
0·4	·0^{2}134672011869	·0^{4}672017811684	·0^{5}268449532285
0·6	·0^{2}460216582095	·0^{3}343620758320	·0^{4}205557100196
0·8	·0111002210296	·0^{2}110125859602	·0^{4}876350693866
1·0	·0221684249243	·0^{2}273712022104	·0^{3}271463155956
1·2	·0393590030648	·0^{2}580066622187	·0^{3}687894919051
1·4	·0645222328531	·0110255569122	·0^{2}151905049781
1·6	·0998922705633	·0193713312135	·0^{2}303561449592
1·8	·148188982086	·0320769381221	·0^{2}562481265409
2·0	·212739959240	·0507285699791	·0^{2}982567932312
2·2	·297627709533	·0773448824914	·0163735913822
2·4	·407868011092	·114483453137	·0262565006355
2·6	·549626665935	·165373259392	·0407858678054
2·8	·730483412160	·234079089848	·0616860125932
3·0	·959753629490	·325705181936	·0912064776610
3·2	1·24888076598	·446647066782	·132263099020
3·4	1·61191521679	·604902664549	·188614829615
3·6	2·06609880918	·810456197666	·265085036586
3·8	2·63257822397	1·07575157832	·367838059088
4·0	3·33727577842	1·41627570765	·504724363113
4·2	4·21195220660	1·85127675241	·685710773430
4·4	5·29550364442	2·40464812914	·923416136884
4·6	6·63554425495	3·10601585905	1·23377754356
4·8	8·29033717554	3·99207544030	1·63687810838
5·0	10·3311501691	5·10823476364	2·15797454732
5·2	12·8451290635	6·51063229818	2·82877168171
5·4	15·9388023977	8·26861530445	3·68900194663
5·6	19·7423554848	10·4677818331	4·78838143757
5·8	24·4148422891	13·2137134973	6·18903056865
6·0	30·1505402994	16·6365544178	7·96846774238

x	$I_6(x)$	$I_7(x)$	$I_8(x)$
0·0	nil	nil	nil
0·2	$\cdot 0^{8}139087425642$	$\cdot 0^{10}198660852119$	$\cdot 0^{12}248291584037$
0·4	$\cdot 0^{7}893980971214$	$\cdot 0^{9}255240920874$	$\cdot 0^{10}637748154995$
0·6	$\cdot 0^{5}102559132723$	$\cdot 0^{7}438834749717$	$\cdot 0^{8}164357788982$
0·8	$\cdot 0^{5}582022868887$	$\cdot 0^{6}331639053615$	$\cdot 0^{7}165452506106$
1·0	$\cdot 0^{4}224886614771$	$\cdot 0^{5}159921823120$	$\cdot 0^{7}996062403333$
1·2	$\cdot 0^{4}682085631142$	$\cdot 0^{5}580928790861$	$\cdot 0^{6}433537513798$
1·4	$\cdot 0^{3}175196213558$	$\cdot 0^{4}173686673046$	$\cdot 0^{5}150954051219$
1·6	$\cdot 0^{3}398740613950$	$\cdot 0^{4}450598913012$	$\cdot 0^{5}446656506452$
1·8	$\cdot 0^{3}827978932673$	$\cdot 0^{3}104953102941$	$\cdot 0^{4}116770209099$
2·0	$\cdot 0^{2}160017336352$	$\cdot 0^{3}224639142001$	$\cdot 0^{4}276993695123$
2·2	$\cdot 0^{2}291946711786$	$\cdot 0^{3}449225284743$	$\cdot 0^{4}607607604085$
2·4	$\cdot 0^{2}508136715570$	$\cdot 0^{3}849664857007$	$\cdot 0^{3}124988823159$
2·6	$\cdot 0^{2}850453706344$	$\cdot 0^{2}153415828186$	$\cdot 0^{3}243684776533$
2·8	·0137719020155	$\cdot 0^{2}266357538382$	$\cdot 0^{3}454025096400$
3·0	·0216835897328	$\cdot 0^{2}447211872992$	$\cdot 0^{3}813702326455$
3·2	·0333248823452	$\cdot 0^{2}729479022559$	$\cdot 0^{2}141017510822$
3·4	·0501531656813	·0116036566222	$\cdot 0^{2}237340311951$
3·6	·0741088738166	·0180554571973	$\cdot 0^{2}389320693838$
3·8	·107756685981	·0275537875687	$\cdot 0^{2}624273178058$
4·0	·154464799871	·0413299635012	$\cdot 0^{2}980992761666$
4·2	·218632053769	·0610477626605	·0151395115677
4·4	·305975090770	·0889386166028	·0229885833970
4·6	·423890764347	·127975549614	·0343999611745
4·8	·581912714514	·182096322090	·0507984417519
5·0	·792285668997	·256488941728	·0741166321596
5·2	1·07068675643	·357956089960	·106958821921
5·4	1·43713021810	·495379239735	·152813670643
5·6	1·91710069457	·680308520639	·216329392995
5·8	2·54297113760	·927710973612	·303668787505
6·0	3·35577484714	1·25691804811	·422966068203

x	$I_9(x)$	$I_{10}(x)$	$I_{11}(x)$
0·0	nil	nil	nil
0·2	$\cdot 0^{14}275848890728$	$\cdot 0^{16}275823817735$	$\cdot 0^{18}25072993174$
0·4	$\cdot 0^{11}141658875600$	$\cdot 0^{13}283214795193$	$\cdot 0^{15}514780037287$
0·6	$\cdot 0^{10}547312431307$	$\cdot 0^{11}164059590224$	$\cdot 0^{13}447130560011$
0·8	$\cdot 0^{9}734041402172$	$\cdot 0^{10}293190617555$	$\cdot 0^{11}106485828421$
1·0	$\cdot 0^{8}551838586274$	$\cdot 0^{9}275294803983$	$\cdot 0^{10}124897830849$
1·2	$\cdot 0^{7}287877246335$	$\cdot 0^{8}172164429560$	$\cdot 0^{10}9365304020$
1·4	$\cdot 0^{6}116775736690$	$\cdot 0^{8}813818331745$	$\cdot 0^{9}51597501248$
1·6	$\cdot 0^{6}394240656000$	$\cdot 0^{7}313576845153$	$0^{9}22695995590$
1·8	$\cdot 0^{5}115736151949$	$\cdot 0^{6}103405714922$	$\cdot 0^{8}84091314720$
2·0	$\cdot 0^{5}304418590271$	$\cdot 0^{6}301696387935$	$\cdot 0^{7}272220233597$
2·2	$\cdot 0^{5}732884540826$	$\cdot 0^{6}797479795484$	$\cdot 0^{7}79029085679$
2·4	$\cdot 0^{4}164060359505$	$\cdot 0^{5}194355352977$	$\cdot 0^{6}20975653574$
2·6	$\cdot 0^{4}345596570386$	$\cdot 0^{5}442561241924$	$\cdot 0^{6}51648458289$
2.8	$\cdot 0^{4}691462615510$	$\cdot 0^{5}951341501153$	$\cdot 0^{5}11932971830$
3·0	$\cdot 0^{3}132372988831$	$\cdot 0^{4}194643934705$	$\cdot 0^{5}26103656940$
3·2	$\cdot 0^{3}243914684482$	$\cdot 0^{4}381550080109$	$\cdot 0^{5}544588441373$
3·4	$\cdot 0^{3}434700765661$	$\cdot 0^{4}720461248306$	$\cdot 0^{4}109000313633$
3·6	$\cdot 0^{3}752315248879$	$\cdot 0^{3}131630693989$	$\cdot 0^{4}210336156069$
3·8	$\cdot 0^{2}126860112417$	$\cdot 0^{3}233568560836$	$\cdot 0^{4}39292909243$
4·0	$\cdot 0^{2}209025303452$	$\cdot 0^{3}403788961327$	$\cdot 0^{4}713082278832$
4·2	$\cdot 0^{2}337343287863$	$\cdot 0^{3}681942087915$	$\cdot 0^{3}126089602839$
4·4	$\cdot 0^{2}534376788633$	$\cdot 0^{2}112771477116$	$\cdot 0^{3}217791653765$
4·6	$\cdot 0^{2}832351074598$	$\cdot 0^{2}182970173372$	$\cdot 0^{3}36828581676$
4·8	·0127681829170	$\cdot 0^{2}291775581322$	$\cdot 0^{3}61086702855$
5·0	·0193157188168	$\cdot 0^{2}458004441917$	$\cdot 0^{3}995541140110$
5·2	·0288520225117	$\cdot 0^{2}708643630312$	$\cdot 0^{2}159649826893$
5·4	·0425979933861	·0108203593556	$\cdot 0^{2}252258836536$
5·6	·0622245406441	·0163219409248	$\cdot 0^{2}393189448412$
5·8	·0900039735967	·0243461108260	$\cdot 0^{2}605186730033$
6·0	·129008532906	·0359404694846	$\cdot 0^{2}920696795753$

Report of the Committee, consisting of Professor FITZGERALD (*Chairman*), Professor BARRETT (*Secretary*), *and* Mr. TROUTON, *appointed to investigate the Molecular Phenomena connected with the Magnetisation of Iron.*

OWING to various causes, it is not proposed on the present occasion to do more than present a formal interim report, reserving to next year the full report of the Committee.

So much work has of late been done on the general subject of the molecular phenomena attending magnetisation, that it would now be beyond the scope of the Committee adequately to report on the whole matter. We propose, therefore, in the first instance, to confine our report to those phenomena accompanying the so-called critical temperature of iron—that point in or near which the magnetic state is lost in heating and regained on cooling. Here, at a dull red heat a series of profound and remarkable changes occur in iron and steel, to which attention was called in a paper 'On certain remarkable Molecular Changes occurring in Iron Wire at a Low Red Heat,' read by the Secretary of this Committee at the meeting of the British Association at Bradford in 1873, and subsequently published in the 'Philosophical Magazine' for December 1873. In this paper the phenomenon known as the *recalescence* of iron was first published, it having been discovered by the author early in September 1873. The principal points in that paper were as follows:—

(1) Mr. Gore, in 1869, had discovered that a momentary *elongation* of iron occurred in cooling after heating a wire of that metal to a white heat. In 1873 the author found a similar but reverse action took place in *heating* the wire. (2) This anomalous deportment was found, both in heating and cooling, approximately to coincide with, on the one hand, the *loss*, and on the other with the *resumption* of the magnetic state of iron or steel. (3) At the critical temperature the wire, having cooled down to a dull red heat, suddenly flashed into a bright glow; likewise, during the *heating* of the wire the temperature remains stationary for a short time when the critical temperature is reached; a rise in the specific heat of iron and steel therefore occurs at the critical temperature. (4) A curious crepitating sound occurs at the critical temperature, similar to that heard in the magnetisation of iron, or in the production of the scales of oxide on the wire. (5) Professor Tait's remarkable thermo-electric change in iron occurs at this same temperature. (6) Hard iron wire and steel wire exhibit recalescence, but certain specimens of good soft iron failed to show it, and even in the wire that exhibits it the phenomenon grows less marked after repeated heating and cooling.

To these observations may be added that a recent investigation by the Secretary of the Committee on the properties of 14 per cent. manganese steel wire ('Proceedings,' Royal Dublin Society, December 1886) shows that this body, which is almost a non-magnetic metal, does *not* exhibit the anomalous deportment observed in ordinary steel wire. This fact is of considerable interest, as linking the foregoing phenomena more closely with the magnetic state of iron and steel.

Estimating the temperature of the critical point approximately from the expansion of platinum brought to the same degree of redness, it was

found, some years ago, to be not above 800° C. The recent admirable investigation of this point by Dr. J. Hopkinson has shown it to be 680° C., rising to 712° C. during recalescence. Dr. Hopkinson has also shown that the temperature at which steel ceases to be magnetic is 690° C., so that he has definitely established the important fact of the identity of the two temperatures.

When we remember that the mechanical, electrical, and thermal properties of iron and steel are of the utmost practical importance, and that all these properties appear to undergo a remarkable change at the critical temperature, the need of a searching investigation on the question is obvious. Moreover, the interest is no less, from a theoretical point of view, in connection with theories as to the molecular structure of magnetised iron and steel.

Recalescence being feeble in soft iron, but marked in hard iron and in steel, it was conjectured that the phenomenon might be due to an action depending on the presence of carbon in iron, creating an effect analogous to that observed when water or super-saturated solutions are cooled below the solidifying point; a slight disturbance of the liquid thereupon producing a sort of explosive action, solidification occurring with a sudden rise of temperature. Professor Roberts-Austen has drawn attention to the fact that lately M. Osmund, in France, has made recalescence the starting-point of a new inquiry, tracing the effects of Carbon, Mn, Cr, S, P, and Si, on the points at which recalescence occurs or is destroyed by the alloy. That whilst pure iron does undergo a molecular change at a red heat, carbon retains its position as an important factor in determining the point of recalescence in hard iron and steel. Messrs. Barus and Strouhal have recently published in America a series of important papers on the tempering of steel, and shown that a critical temperature of between 500° and 1,000° C. exists, which is intimately connected with the hardening or annealing of steel. They also draw attention to the numerous phenomena observed to occur at this temperature. Numerous other experimenters have worked at recalescence, notably Mr. Tomlinson, of King's College, and Mr. Newall, at Cambridge, but the bibliography and discussion of the whole subject will be reserved to the report next year.

Report of the Committee, consisting of Mr. JOHN MURRAY (*Secretary*), Professor SCHUSTER, Sir WILLIAM THOMSON, *the* Abbé RENARD, Mr. A. BUCHAN, *the* Hon. R. ABERCROMBY, *and* Dr. M. GRABHAM, *appointed for the Collection and Identification of Meteoric Dust.*

SEVERAL of the members of this Committee have had informal meetings, and collections of dust have been received from several important stations in Oceanic Islands. Others are expected soon, and it is believed a detailed report can be drawn up before the next meeting of the Association. No money grant is required.

Eighteenth Report of the Committee, consisting of Professor EVERETT, Professor Sir WILLIAM THOMSON, Mr. G. J. SYMONS, Sir A. C. RAMSAY, Dr. A. GEIKIE, Mr. J. GLAISHER, Mr. PENGELLY, Professor EDWARD HULL, Professor PRESTWICH, Dr. C. LE NEVE FOSTER, Professor A. S. HERSCHEL, Professor G. A. LEBOUR, Mr. A. B. WYNNE, Mr. GALLOWAY, Mr. JOSEPH DICKINSON, Mr. G. F. DEACON, Mr. E. WETHERED, *and* Mr. A. STRAHAN, *appointed for the purpose of investigating the Rate of Increase of Underground Temperature downwards in various Localities of Dry Land and under Water. (Drawn up by* Professor EVERETT, *Secretary.)*

VERY important observations have been published[1] during the past year by Herr Dunker, whose observations in a very deep bore at Sperenberg were embodied in our Report for 1876. The new observations were taken at Schladebach, near Dürrenberg, in a bore of greater depth and smaller diameter than that at Sperenberg, and with similar precautions against convection currents. The depth was 1,748 metres, the bore passing through new red sandstone (Buntsandstein), magnesian limestone (Zechstein), lower Permian sandstone (Rothliegendes), and coal-measures (Steinkohlengebirge), to the upper Devonian beds (Oberdevon).

It was tubed to the depth of 1,240 metres. For the first 584 metres the diameter was 120 millimetres; for the next 104 m. it was 92 mm.; then for 393 m. it was 72 mm., and for the next 159 m. it was 50 mm. From this point to the bottom the diameter gradually diminished to that of a man's little finger. The diamond borer was the instrument employed in sinking it.

Indiarubber bags, such as were used at Sperenberg for preventing convection currents, being deemed unsuitable for such a narrow bore, a plugging of moist clay was employed, constructed as follows:—

On a cylindrical rod, which might be of tough wood for bores of moderate depth, but was of iron in the actual observations, are two wooden discs of such size that there is only just room for them to move in the bore. The lower disc is fixed, and the upper movable on the rod. The part of the rod below the fixed disc has a length equal to that of the water-column which it is desired to isolate. The maximum thermometer with which the temperatures are taken has its bulb half way down this portion of the rod. It is fastened beside the rod if there is room for it; and when the bore is too narrow for this arrangement, the thermometer is placed in a metal box which may be described as forming part of the rod, the rod being divided into two portions screwed to the two ends of the box. The movable disc is removed to a measured distance from the fixed one, and the space between them is then filled with clay which has been made plastic by kneading it with water, so that it forms a cylinder with the two discs.

When the pole presses on the bottom of the bore, part of the weight of the boring rods is supported on the upper disc, thus squeezing the clay against the sides of the bore and forming a water-tight plug.

[1] *Neues Jahrbuch für Mineralogie*, &c., 1889, Bd. 1.

The above description applies especially to the taking of observations at the bottom of the bore. When it was desired to isolate a column of water at a considerable distance from the bottom, the apparatus employed consisted of two portions. The above description applies to the upper portion, and the lower portion was similar to it but inverted, resting upon rods which extended to the bottom. The two masses of clay in this case cut off a water-column between them.

Experiments with a model, in which the bore was represented by a cylindrical glass vessel 26 cm. high and 55 mm. wide, filled with water, showed that the isolation was very good, and that it remained so though the immersion lasted more than ten hours. In tearing away the clay from the vessel a portion of the clay fell into the water, but such an accident occurring in the bore would be of no consequence.

The construction of the isolating apparatus was entrusted to Bore-Inspector Köbrich, under whose management the observations were to be carried out.

Besides the thermometer in the isolated water-column, there was a second maximum thermometer in the open water just above the upper plug, for comparison, the height of its bulb above that of the principal thermometer being 2·8 m.

The thermometers were very similar to those employed at Sperenberg. They were overflow-thermometers, generally without scales, and were enclosed (for protection against pressure) in a hermetically sealed case of stout glass with an external diameter of 15 mm. To take the reading, the thermometer, after being drawn up, was put with a normal thermometer into a vessel of water at a temperature a little below that which was expected. Warm water was then gradually added, and the whole kept stirred till the mercury in the overflow-thermometer reached the open end. The temperature at this moment was then read by the other thermometer.

In the annexed figure, *ab* is the thermometer, enclosed in the strong glass tube *c*, to which it is not fastened. A quantity of loose mercury, the surface of which is shown at *x*, is also contained in this tube. Overflow takes place at the end *b*, which is cut off obliquely so that any mercury which issues from the tube will run down the slope. To refill the thermometer, the instrument is warmed till overflow commences, and is then promptly inverted. The thermometer thus slips down to the other end of the case, and its open end, *b*, is immersed in the loose mercury, some of which is drawn into the thermometer as it cools.

The first observations taken were in the untubed portion of the bore, which at that time extended from the depth of 1,240 m. to 1,376 m.; and as the bore was deepened to 1,748 m. the observations were continued. In this way the last sixteen observations of Table I. were obtained, forming a series at intervals of 30 m. from 1,266 m. to 1,716 m. of depth.

A pause which subsequently occurred in the sinking of the bore, through having to wait for a new tube, was utilised for taking the observations which form the remainder of the Table. We have thus a complete series of observations, at equal intervals of 30 m., from the depth of 6 m. to that of 1,716 m.

The Table is arranged in five columns. The first column contains the natural numbers from 1 to 58, for convenience of reference to the observa-

TABLE I.

Distinctive number	Depth in metres	Temperature Réaumur	Non-isolated colder by	Increase for 30 m.
		°	°	°
1	6	8·3	0·4	—
2	36	8·8	0·3	0·5
3	66	9·6	0·2	0·8
4	96	10·3	0·7	0·7
5	126	10·9	0·8	0·6
6	156	11·3	0·4	0·4
7	186	12·2	0·9	0·9
8	216	13·0	0·9	0·8
9	246	13·6	0·2	0·6
10	276	14·3	0·1	0·7
11	306	14·5	0·1	0·2
12	336	15·2	0·6	0·7
13	366	15·4	0·3	0·2
14	396	16·6	1·0	1·2
15	426	17·1	0·5	0·5
16	456	17·7	0·5	0·6
17	486	18·3	0·5	0·6
18	516	19·0	0·6	0·7
19	546	19·8	0·3	0·8
20	576	20·6	0·1	0·8
21	606	21·1	0·2	0·5
22	636	21·3	0·1	0·2
23	666	22·0	0·0	0·7
24	696	22·9	0·1	0·9
25	726	23·3	0·1	0·4
26	756	23·9	0·0	0·6
27	786	24·8	0·0	0·9
28	816	25·2	0·2	0·4
29	846	26·3	0·1	1·1
30	876	27·2	0·1	0·9
31	906	27·8	0·1	0·6
32	936	28·5	0·0	0·7
33	966	29·3	0·1	0·8
34	996	29·8	0·2	0·5
35	1,026	30·1	0·1	0·3
36	1,056	30·4	0·0	0·3
37	1,086	31·3	0·0	0·9
38	1,116	32·2	0·1	0·9
39	1,146	32·7	0·1	0·5
40	1,176	33·7	0·3	1·0
41	1,206	34·4	0·1	0·7
42	1,236	35·2	0·0	0·8
43	1,266	36·2	0·3	1·0
44	1,296	36·9	0·1	0·7
45	1,326	37·7	0·0	0·8
46	1,356	38·8	0·2	1·1
47	1,386	39·7	0·1	0·9
48	1,416	40·4	0·4	0·7
49	1,446	40·9	0·0	0·5
50	1,476	41·5	0·0	0·6
51	1,506	42·3	0·2	0·8
52	1,536	42·5	0·2	0·2
53	1,566	42·8	0·6	0·3
54	1,596	43·6	0·1	0·8
55	1,626	44·0	0·1	0·4
56	1,656	44·4	0·4	0·4
57	1,686	45·2	0·1	0·8
58	1,716	45·3	0·0	0·1

tions at the 58 different depths; the second column contains the depths in metres; and the third column, the temperatures observed at these depths in isolated water-columns. The fourth column contains the excess of the temperature so observed above the temperature observed by means of the secondary thermometer in the free water just above the plug. The fifth column contains the differences between the successive numbers in the third column—in other words, the increase of temperature for each 30 m. of depth.

The smallness of the effect of isolation, as shown in the fourth column of the Table, is very noteworthy, its greatest value being 1° R., and its average value about $\frac{1}{4}$ of 1° R. At Sperenberg it amounted in several cases to about 3° R. The smallness of the effect in the present case is attributable to the narrowness of the bore, which tells in two ways: there is more frictional resistance to the movement of the water; and the thermal capacity of a given length of column is less in comparison with its surface of contact with the sides of the bore.

As a further experiment on the prevention of convection, a wooden plug was driven into the bore at the depth of 438 m., thick mud was introduced till it filled all the bore above this plug, and observations were taken with a maximum thermometer in the mud at depths from 426 m. to 126 m. A second plug was then driven in at the top of the tubing, which was 120 m. beneath the surface of the ground, and the observations were continued upwards from 118 m. to 6 m. The observations thus taken in the mud are given in the second column of Table II. They are rather higher than those previously obtained at the same depths, which are repeated from Table I. for comparison, the greatest difference occurring at the depth of 276 m., where it amounts to 0°·9 R. Herr Dunker suggests that the difference may have arisen from insufficient time being allowed for the mud to take the permanent temperature.

Table II.

Depth	Observations in thick mud		Observations in isolated column	
	Temperature Réaumur	Increase for 30 m.	Temperature Réaumur	Increase for 30 m.
m.	°	°	°	°
6	8·2	—	8·3	—
36	8·6	0·4	8·8	0·5
66	9·0	0·4	9·6	0·8
96	9·9	0·9	10·3	0·7
118	10·6	—	—	—
126	—	—	10·9	0·6
156	—	—	11·3	0·4
186	—	—	12·2	0·9
216	12·5	—	13·0	0·8
246	12·9	0·4	13·6	0·6
276	13·4	0·5	14·3	0·7
306	14·2	0·8	14·5	0·2
336	14·6	0·4	15·2	0·7
366	15·2	0·6	15·4	0·2
396	16·4	1·2	16·6	1·2
426	17·0	0·6	17·1	0·5
Total increase	8·8		8·8	

Upon the whole it is clear that in this great bore the disturbing effect of convection is very small, and that, such as it is, it has been almost annihilated by the very efficient system of plugging adopted. The series of observations now before us, extending as it does by regular stages from the surface to a depth of 5,630 feet, in a new bore where there has not been time for the original heat to be lost by exposure, forms undoubtedly the most valuable contribution ever made to the observation of underground temperature. The official to whose initiative the observations are due is Chief-Mining-Captain Huyssen of Berlin. The expense of sinking the bore was 10,000*l.* sterling, the time required for hauling up the boring rods was 10 hours, and their united weight was 20 tons.

On plotting the temperatures so as to exhibit temperature as a function of depth, the curve obtained approximates very closely to a straight line. A straight line joining its two ends meets the curve several times in the part corresponding to the tubed portion of the bore, which is about three fourths of the whole; while in the remaining fourth (forming the deepest portion of the bore) all the temperatures except the first and last lie above the straight line. In this statement it is to be understood that depth is represented by distance laid off horizontally, and temperature by distance laid off vertically upwards.

The question whether the curve on the whole bends upwards or downwards is of some interest, because it is equivalent to the question whether the rate of increase is accelerated or retarded as we go deeper. The evidence on this point is undecisive. The curve for the untubed portion, from 1,266 m. to 1,716 m., lies slightly above its chord; but the curve from either 6 m. or 36 m. to 1,500 m. lies for the most part below its chord.

Taking the observation at 36 m. as the first which is free from atmospheric disturbance, and comparing it with the deepest observation of all, which is at 1,716 m., we have an increase of 36·5° Réaumur in 1,680 m. This is a difference of 82·1° Fahrenheit in 5,512 feet, which is at the rate of 1° F. in 67·1 feet.

Herr Dunker, after an elaborate discussion of the question whether the curve on the whole bends upwards or downwards, arrives at the conclusion that it is best represented by a straight line. He applies the method of least squares to find the slope of this straight line, and thus obtains a mean rate of increase of ·0224276 of a degree Réaumur per metre, which is equivalent to 1° F. for 65·0 feet.

The Secretary has been in correspondence with Mr. George Westinghouse, junr., of Pittsburgh, President of the Philadelphia Company, with the view of obtaining observations of temperature from some of the deep oil and gas wells belonging to the Company. Mr. Westinghouse has purchased three of the Committee's maximum thermometers, and has entrusted the taking of the observations to Mr. A. Cummins, the Company's Mining Engineer and Geologist. Some attempts have been made at observation, but owing to press of business they have not been thoroughly carried out. Mr. Cummins states that 'there has been a constant strain to bring up the supply of gas to the requirement of the city's needs, and every hour of delay is watched very jealously.'

The most successful attempt was made in a well at Homewood in the city of Pittsburgh, known as the Dilworth well, where the following results were obtained :—

Depth in feet	Temperature F.	Air at surface
3,600	° 96	° 70
3,710	89	76
3,920	102	60
4,002	108	62
4,215	111	62
4,295	114	62

The well was sunk to a depth of 4,625 feet, but no observations were made except at the depths specified. The thermometer remained only from five to ten minutes during each test; and as there were only 40 feet of water in the well, the observations must have been taken in air. The diameter of the well was 6 inches. The rock was chiefly slate, and was bored by 'jumping.' The mean air temperature at Pittsburgh is 52° F., and the height above sea-level about 900 feet. Comparison of the mean surface-temperature (taken as 52°) with the temperature, 114°, recorded at 4,295 feet shows an increase of 62°, which is at the rate of 1° F. for 69·3 feet; but comparison of the observations *inter se* would give a rate about twice as rapid as this; hence no safe conclusion can be drawn. After the hurry and worry of the gas business is over, Mr. Cummins hopes to get the temperature of some deep wells in a way that will be satisfactory.

We may mention, as a contribution to the literature of Underground Temperature, the recent publication of results obtained at the Old Observatory, Allahabad, with thermometers whose bulbs were at the depths 3 feet, 1 foot, and half an inch respectively. Harmonic reduction has been applied to deduce both the annual and the diurnal variation, and from the former a fairly consistent determination of the 'diffusivity,' or quotient of conductivity by capacity, has been obtained. Its value, ·0054 C.G.S., is smaller than any values that have been found elsewhere. The soil is a sandy loam, which in dry weather becomes almost as hard as brick. The observations extend over six years, and similar observations are now being carried on at the New Observatory. The gentleman who is reponsible for the reductions and the description of the observations is Mr. S. A. Hill, B.Sc., Meteorological Reporter to Government for the North-Western Provinces.

Fifth Report of the Committee, consisting of Sir G. G. Stokes *(Chairman)*, Mr. G. J. Symons *(Secretary)*, Professor Schuster, Dr. G. Johnstone Stoney, Sir H. E. Roscoe, Captain Abney, *and* Mr. Whipple, *appointed for the purpose of considering the best methods of recording the direct Intensity of Solar Radiation.*

The actinometer devised by the late Professor Balfour Stewart for the continuous measurement of solar radiation, which was described in the Report of the Association for 1887 (p. 32), is now ready for the preliminary trials, the internal thermometer, with a flat bulb of green glass, having been made since the date of that report. The construction of this thermometer

occasioned a good deal more trouble than had been anticipated. No attempt has at present been made to render the instrument self-registering, as it would obviously be unwise to incur the outlay which any construction for this purpose would involve, unless the result of preliminary trials were such as to encourage a hope that the instrument might be really useful if rendered self-recording.

Report of the Committee, consisting of Professor G. CAREY FOSTER, Sir WILLIAM THOMSON, Professor AYRTON, Professor J. PERRY, Professor W. G. ADAMS, Lord RAYLEIGH, Dr. O. J. LODGE, Dr. JOHN HOPKINSON, Dr. A. MUIRHEAD, Mr. W. H. PREECE, Mr. HERBERT TAYLOR, Professor EVERETT, Professor SCHUSTER, Dr. J. A. FLEMING, Professor G. F. FITZGERALD, Mr. R. T. GLAZEBROOK (*Secretary*), Professor CHRYSTAL, Mr. H. TOMLINSON, Professor W. GARNETT, Professor J. J. THOMSON, Mr. W. N. SHAW, Mr. J. T. BOTTOMLEY, *and* Mr. T. GRAY, *appointed for the purpose of constructing and issuing Practical Standards for use in Electrical Measurements.*

THE Committee report that the work of testing resistance coils has been continued at the Cavendish laboratory. A table of the values found for the various coils is appended.

Legal Ohms.

No. of Coil		Resistance in Legal Ohms	Temperature
Nalder Bros., 1429 . .	No. 182	1·00027	12°·6
Nalder Bros., 1427 . .	No. 183	·99875	12°·6
Elliott, 208 . . .	No. 184	·99876	12°·4
Jas. White, Glasgow . . .	No.	·99955	12°·1
Jas. White, Glasgow . . .	No.	9·9974	12°
Elliott, 209 . . .	No. 185	·99977	14°·6
Elliott, 210 . . .	No. 186	·99973	14°·7
Elliott, 218 . . .	No. 187	·99974	14°·9
Elliott, 221 . . .	No. 188	1·00095	18°·1

In March 1889 a coil of platinum silver, marked 'Elliott, No. 95,' which had been tested for Professor Roiti, of Florence, in November 1883, was again compared. It was found to have the value of ·99903 B.A. units at 12·8° Centigrade. The value given to Professor Roiti in 1883 was:—

$$R = \cdot 99977 \{1 + \cdot 00031 (t - 15\cdot 2)\}$$

This leads, at 12·8°, to exactly the same value, ·99903, as found in 1889.

Thus, in the five-and-a-half years between these two tests, this coil has not changed relatively to the standards.

Further steps have been taken towards the construction of an air-condenser. As stated in the last report, Dr. Alexander Muirhead kindly placed at the disposal of the Committee, for the purpose of experiment, three such condensers which he had constructed. A series of tests of these condensers was carried out by the secretary, and laid before a meeting of the Committee in London on April 15th. It was then decided to adopt Dr. Muirhead's form of condenser for the new instruments of the Committee, and two condensers, each having a capacity of about ·01 microfarad, have been ordered from the Cambridge Scientific Instrument Company. It was hoped that these would have been completed early this summer, but great difficulties have been met with in obtaining the brass tubes required for their construction, and, though well advanced, they are not yet finished. A detailed description of their design is therefore left to the next report.

A second subject of investigation has been the specific resistance of copper. During the year Mr. T. C. Fitzpatrick has made a large series of experiments to determine this, and the Committee desire to thank cordially those manufacturers and others who have given him assistance in this research. They would specially mention the firms of Messrs. Thomas Bolton and Sons, of Cheadle, and Messrs. Frederick Smith and Co., of Halifax.

Before publishing the results of this investigation, Mr. Fitzpatrick is desirous of experimenting on some copper which is being prepared for him by chemical means—all which has been used hitherto has been electrically deposited—and of attempting still further to purify some of the copper already in his possession.

Two members of the Committee, Sir William Thomson and Mr. Preece, were present at the recent Electrical Congress in Paris. They report that the following resolutions, several of which have already been agreed to by the Committee, were unanimously adopted.

(1) L'unité pratique de travail est le joule. Il est égal à 10^7 unités C. G. S. de travail. C'est l'énergie dépensée pendant une seconde par un ampère dans un ohm.

(2) L'unité pratique de puissance est le watt. Il est égal à 10^7 unités C. G. S. de puissance. Le watt est égal à un joule par seconde.

Dans la pratique industrielle, on exprimera la puissance des machines en kilowatts, au lieu de l'exprimer en chevaux-vapeur.

(3) Pour évaluer l'intensité d'une lampe en bougies, on prendra comme unité pratique, sous le nom de bougie décimale,[1] la vingtième partie de l'étalon absolu de lumière défini par la Conférence internationale de 1884.

(4) L'unité pratique de coefficient d'induction est le quadrant.

$$1 \text{ quadrant} = 10^9 \text{ centimètres.}$$

(5) La période d'un courant alternatif est la durée d'une oscillation complète.

(6) La fréquence est le nombre de périodes par seconde.

(7) L'intensité moyenne est définie par la relation

$$I_{moy} = \frac{1}{T}\int_0^T I\,dt.$$

[1] La bougie décimale, ainsi définie, se trouve être très sensiblement égale à la bougie anglaise (*Candle standard*) et au dixième de la Carcel.

(8) L'intensité efficace est la racine carrée du carré moyen de l'intensité du courant.

(9) La force électromotrice efficace est la racine carrée du carrée moyen de la force électromotrice.

(10) La résistance apparente est le facteur par lequel il faut multiplier l'intensité efficace pour avoir la force électromotrice efficace.

(11) Dans un accumulateur, la plaque positive est celle qui est reliée au pôle positif de la machine pendant la charge, et qui est le pôle positif pendant la décharge.

(12) Le Congrès recommande comme moyen de déterminer le degré d'incandescence d'une lampe, la méthode proposée par M. Crova.

Ces diverses propositions sont adoptées à l'unanimité.

As an English equivalent of the above the Committee have adopted the following resolutions, which they hope will meet with general acceptance.

(1) The name of the practical unit of work shall be the Joule. The Joule is equivalent to 10^7 C.G.S. units of work. It is the energy expended during 1 second by a current of 1 ampère when traversing a resistance of 1 ohm.

(2) The name of the practical unit of power shall be the Watt. The Watt is the rate of working of a machine performing 1 joule per 1 second. The power of a machine would naturally be expressed in kilowatts instead of in horse-power.

(3) The name of the practical unit of light intensity shall be the Candle.[1] The Candle is equal to the twentieth part of the absolute standard of light as defined by the International Conference of 1884.

(4) The name of the practical unit of induction shall be the 'Quadrant.' One Quadrant is equal to 10^9 centimetres.

(5) The 'Period' of an alternating current is the duration of a complete oscillation.

(6) The 'Frequency' of an alternating current is the number of complete oscillations per second.

(7) The 'Mean Current' through a circuit is the time average of the current and is defined by mean current$=\frac{1}{T}\int_0^T i\,dt$, i being the current at each instant of the time T.

(8) The 'Effective Current' is the square root of the time average of the square of the current. Thus, effective current$=\sqrt{\left\{\frac{1}{T}\int_0^T i^2\,dt\right\}}$

(9) The 'Effective Electromotive Force' is the square root of the time average of the square of the electromotive force. Thus, effective electromotive force $=\sqrt{\left\{\frac{1}{T}\int_0^T e^2\,dt\right\}}$, e being the actual electromotive force at each instant of the time T.

(10) The 'Impedance' is the factor by which the effective current

[1] It will be seen that the Committee recommend the names 'Candle' and 'Impedance' as the equivalents for the French terms 'Bougie décimale' and 'Résistance apparente' respectively. With regard to the latter, they are of opinion that it is desirable to restrict the term 'Resistance' to actions purely dissipative.

The candle is also very approximately equivalent to the English standard candle and to one-tenth of the Carcel.

must be multiplied to give the effective electromotive force. Thus, in the case of a circuit of resistance R ohms, and self-induction L quadrants, in which a simple harmonic electromotive force of frequency, $n/2\pi$, is acting, Impedance $= \sqrt{\{R^2 + L^2 n^2\}}$.

(11) In an Accumulator the positive pole is that which is connected with the positive pole of the machine when charging, and from which the current passes into the external circuit when discharging.

Of the 100*l.* voted to the Committee last year, 75*l.* has been drawn from the treasurer; 60*l.* towards defraying the cost of the air-condensers, and 15*l.* for some resistance coils and thermometers required for testing.

The Committee are of opinion that they should be reappointed, with the addition of the name of Prof. J. Viriamu Jones, and with a grant of 50*l.* to continue the experiments which are now in progress.

They propose that Prof. G. Carey Foster should be the Chairman and Mr. R. T. Glazebrook the Secretary.

Second Report of the Committee, consisting of the Hon. RALPH ABERCROMBY, Dr. A. BUCHAN, Mr. J. Y. BUCHANAN, Mr. J. WILLIS BUND, Professor CHRYSTAL, Mr. D. CUNNINGHAM, Professor FITZGERALD, Dr. H. R. MILL (*Secretary*), Dr. JOHN MURRAY (*Chairman*), Mr. ISAAC ROBERTS, Dr. H. C. SORBY, *and the* Rev. C. J. STEWARD, *appointed to arrange an investigation of the Seasonal Variations of Temperature in Lakes, Rivers, and Estuaries in various parts of the United Kingdom in co-operation with the local societies represented on the Association.*

No formal meeting of the Committee has been held, but some of the members have occasionally met informally, and the whole Committee has been consulted by letter on all the arrangements which have been completed. It is inadvisable to attempt at present to summarise the results of observations made, as, although more than a year's observations are available on some rivers, it is only a few months since the work has been begun on others. At the end of another year it is expected that sufficient data will be found to justify a comprehensive report on the subject.

Several members of the Committee have taken much trouble in collecting observations. Dr. Sorby has been good enough to collect and discuss a great mass of temperature observations which he had made from his yacht *Glimpse*, in the estuaries of the south-east of England during the summer months of five successive years. This will be published separately. Professor Fitzgerald took charge of the observations in Ireland, where he induced a number of observers to take up the work. Mr. Willis Bund had already inaugurated similar researches on the Severn. Rev. C. J. Steward and Mr. Isaac Roberts rendered important services in their districts.

A circular was sent to all the Corresponding Societies in connection with the Association, requesting their co-operation, and favourable replies were received from several, intimating that observations had been commenced.

Many observers came forward in response to a letter in the newspapers,

and records of river temperature extending over several years were offered by some previous observers. Amongst these Mr. Chapman, of Magdalen College, Oxford, has offered observations on the Cherwell; Mr. John Hunter, of Belper, on the Derbyshire Derwent; Mr. F. C. Bayard, on the Wandle; and Mr. N. Whitely, of Truro, on the Allen.

The form of thermometer employed is described in last year's report. The instructions issued to observers are given as an appendix to the present report.

The observers at work for the Committee now are:—

River, &c.	Observer	Residence
	IN ENGLAND.	
Aire	Rev. E. P. Knubley	Leeds
Avon	Mr. C. Duke	Hill Wooton
"	Mr. S. W. Sutcliffe	Clifton
Bristol Channel	—	Lightship
Cherwell	Mr. J. Chapman	Oxford
Derwent	Mr. J. Hunter	Belper
Dove	Mr. H. H. Brindley	Uttoxeter
Kennet	Mr. W. B. Maurice	Marlborough
Lugg	Mr. A. Ward	Aymstrey
Nene	Mr. Eunson	Northampton
"	Mr. H. Hill	Oundle
Nidd	Mr. G. Paul	Knaresborough
Stour (Worcester)	Mr. E. Collins	Stourport
Stour (Kent)	Mr. W. P. Mann	Canterbury
Luff	Mr. Pettigrew	—
Thames	Mr. J. Hepworth	Rochester
"	—	'Warspite' training-ship
Trent	Mr. T. S. Morris	Burton-on-Trent
Wandle	Mr. F. C. Bayard	Croydon
Waveney	Rev. C. J. Steward	Somerleyton
Water Works	Mr. H. Preston	Grantham
" "	Mr. W. Watts	Manchester
Sea	Mr. McDakin	Dover
	IN SCOTLAND.	
Almond	Mr. J. Paterson	Almond Bank
Aray	Mr. G. Taylor	Inveraray
Ayr	Mr. A. Donald	Muirkirk
Clyde	Mr. W. W. B. Rogers	Greenock
Dee	Mr. McKay	Kincardine O'Neil
Don	Mr. W. Muirhead	Aberdeen
Earn	Mr. J. Ellis	Bridge of Earn
Eden	Mr. F. G. Peddie	Cupar Fife
Forss	Mr. Smith	Forss
Glass	Rev. C. C. McKenzie	Fasnakyle
Leithen	Mr. J. McKenzie	Innerleithen
Nith	Rev. Mr. Andson	Dumfries
Tay and Braan	Dr. Dickson	Dunkeld
Thurso	Mr. D. Campbell	Thurso
"	Mr. A. Harper	Halkirk
Tummel	Mr. J. Kennedy	Logierait
Tweed	Mr. W. Burgess	Peebles
Wick	Mr. J. Simpson	Wick
Water Works	Mr. J. Wilson	Greenock
Sea	Mr. W. Kerr	Scrabster

River, &c.	Observer	Residence
	IN IRELAND.	
Annabuoy	Mr. M. H. Westropp	Carrigaline
Bann	Mr. A. Mulligan	Rathfriland
Barrow	Mr. P. R. Burchell	Graigrie
"	Mr. H. H. Jellet	Monasterevan
Belvidere Lake	Mr. J. Bayliss	Mullingar
Blackwater	Mr. McClure	Kenmare
Boyne	Mr. P. Malone	Trim
Shannon	Mr. F. A. Waller	Banagher
Water Works	Mr. G. E. Riley	Woodburn
Sea	Mr. W. Towrie	Moville
"	Mr. B. Kernan	Warrenpoint
	IN ISLE OF MAN.	
Sea	Mr. J. Henderson	Douglas

In many cases observers willingly paid for their thermometers, but a number of instruments had to be supplied gratis in order to secure observations at interesting places.

The Committee have to thank Mr. John Gunn for his services in forwarding thermometers and observation books and corresponding with observers.

The Committee ask to be re-appointed, with the addition of the name of the Rev. Mr. Andson and with a grant of 50*l*.

APPENDIX.

DIRECTIONS TO OBSERVERS ACTING UNDER A COMMITTEE OF THE BRITISH ASSOCIATION, APPOINTED TO INVESTIGATE THE SEASONAL VARIATION OF TEMPERATURE IN LAKES, RIVERS, AND ESTUARIES IN VARIOUS PARTS OF THE UNITED KINGDOM.

1. *Purpose of the Work.*—The Committee wish to ascertain the relation between the climate and weather of different parts of the country and the temperature of the surface water; this can only be done by the co-operation of a large number of observers with instruments of the same kind used in the same manner.

2. *Care in Observing.*—Observations are quite useless unless they are trustworthy. It is very easy to read a thermometer, and on this account mistakes are often made through carelessness. The most vigilant attention to details is absolutely essential in every separate observation.

3. *The Thermometer.*—The thermometer is sent enclosed in a pasteboard cylinder, packed inside the tin case in which it is to be fixed for use, the whole being enclosed in a tin cylinder, and surrounded by paper folded so as to reduce the shock of an accidental fall in transit. Great care must be taken in unpacking and handling the thermometer. The slit in the cross-bar at the upper end of the japanned tin case is to be widened, if necessary, by pushing a pencil through it, and the thermometer is then to be slipped in bulb first, without forcing it, until the shoulder, just above the bulb, rests in the hole of the lower cross-bar.

Care must be taken never to turn the case upside down while the thermometer is in it.

4. *Reading the Thermometer.*—The paper scale inside the wide glass tube, and behind the narrow tube containing the thread of mercury, is divided into degrees; the mark of each ten degrees is numbered from 10 to 140; and the mark of each five degrees is a little longer than the others. The thermometer should be read to *tenths of a degree*, and the reading put down as a decimal fraction. To read the thermometer, the instrument must be held perpendicularly, with the top of the mercury thread on a level with the eye. Suppose the top of the thread of mercury to be exactly at the second degree mark above the long one numbered 40, then the temperature it records is to be written down as 42·0; should the top of the mercury just barely appear above this mark, it is to be written 42·1 (that is, 42 degrees and one-tenth); if decidedly above the second mark above 40, and apparently not quite one-quarter of the way to the third mark, it is 42·2; if scarcely beyond a quarter of the way, 42·3; if almost half way 42·4; if exactly half way between the two marks, it is 42·5 (that is, 42 degrees and five-tenths, or one-half); if a little beyond half way, it is 42·6; if very nearly three-quarters of the way, 42·7; if a little over three-quarters, it is 42·8; and if almost up to the third mark above 40, it is 42·9. The same way of reckoning applies to the position of the mercury thread between any two degree marks. A tenth of a degree is a very small amount, and the observer need not be discouraged if at first he fails to read so closely; if he perseveres, by cautious guessing he will soon become proficient. Mistakes are more often made in reading the degree than the fraction; for instance, one is more apt to write 44·3 than 43·4 when the true reading is 43·3. Special care must be taken to avoid this.

5. *Selection of Observing Station.*—In a *lake*, an *estuary*, or the *sea*, the observation should be made in a boat at some distance from the shore; failing this, an observation may be made at the end of a pier or a steep rock, provided the depth at low tide is at least three feet, and that the current does not flow over rocks or ground which remain dry at low tide.

In a *river* it is best to note the temperature in mid-channel from a boat; but in rapid streams an observation from the shore is equally satisfactory. The best position is in a rapid run where the depth exceeds three feet. Quiet pools and shallow shelving shores are to be avoided.

It is important to describe minutely the nature of the river at the point where observations are made, the direction in which it flows, the height of the banks, the degree of exposure to the sun, and especially to wind; and a sketch map should be made in the observing book, to show exactly at what point the thermometer is used. It is necessary to observe always at the same place, which should be near the observer's house, or in the line of his regular walks.

6. *Hour of Observing.*—The temperature should be observed once every day at the same hour. The Committee recommend 9 A.M., when that is practicable; or, failing this, 10 or 12. If convenient to the observer, a second observation may be made in the afternoon or evening, but at the same hour every day.

7. *Observing the Weather.*—The date and precise hour of observation is to be entered in the observing book. The column 'Remarks on State of River and Weather' is then to be filled up with as much accuracy as possible. If there is a flood-gauge in the neighbourhood, its indication

should be recorded; if not, the state of the river as regards flood must be put down from general recollections of its average state; the terms *very low, low, average height, slight flood, flood, heavy flood* may be conveniently employed. The direction and force of the wind should be carefully recorded; this is very important, especially in work on lakes, estuaries, and the sea. The amount of cloud at the time, and the state of the weather since the last observation, should be put down generally, noting especially the fall of rain, snow, or hail.

8. *Taking the Temperature.*—The thermometer is to be drawn carefully out of its case, held by the glass ring at the top, and examined to see that the thread of mercury is in free connection with the bulb. See that the thread runs up when the fingers are laid lightly on the bulb, so as to warm it, and that the thread runs down again on withdrawing the fingers. If the thread has got detached from the mercury in the bulb, it may be restored to its position by swinging the tube held at arm's-length by the upper part through a vertical semi-circle *downwards*; this may require to be repeated several times.

Temperature of Air.—Having seen that the thermometer is in order and the bulb perfectly dry, hold it perpendicularly by the upper glass ring exposed to the wind, and, if possible, shaded from the sun, for two minutes; read it as explained in No. 4, and enter the result under 'Temperature of Air.'

Temperature of Water.—Slip the thermometer gently into the japanned tin case to the ring of which a cord about six feet long should be attached. Let the instrument sink in the water, well clear of the shore or the side of the boat, until only the ring and the upper inch of the case are above water; keep it in this position, moving it gently about, for two minutes, raise it carefully, so that the water retained in the cup surrounding the thermometer-bulb is not spilled; hold it by the ring of the tin case, having the top of the mercury-thread on a level with the eye, and read as directed in No. 4, recording the result under 'Temperature of Water.'

After the observation, withdraw the thermometer, dry it carefully, dry the tin case also, re-insert the thermometer, and hang it up in a safe place out of the sun, and not too near a fire, until required for use again.

9. *The Observation Book.*—The observer's name, station, and the number of his thermometer to be entered on the first page. All the observations should be entered in the book at the time they are taken; the best memory must not be trusted. Each day the readings should be copied into a spare book, to be kept by the observer. When the original book is filled, it is to be posted to John Gunn, Esq., F.R.S.G.S., Royal Scottish Geographical Society, 80A Princes Street, Edinburgh, to whom all communications regarding thermometers or observing books are to be addressed.

Letters connected with the observations, especially with reference to thermometers, ought to be marked 'Temperatures' on the envelope.

10. *Accidents to Thermometers.*—If a thermometer is broken in transit, or otherwise, it should be immediately returned, together with its case and packing cylinders, and a statement of the way in which the accident happened, to Mr. Gunn, who will forward another as soon as possible, so that the least delay may take place.

Report of the Committee, consisting of Mr. GLAISHER, Mr. W. H. M. CHRISTIE, Sir R. S. BALL, *and* Dr. LONGSTAFF, *appointed to consider the proposals of* M. TONDINI DE QUARENGHI *relative to the Unification of Time, and the adoption of a Universal Prime Meridian, which have been brought before the Committee by a letter from the Academy of Sciences of Bologna.*

MR. CHRISTIE and Dr. Longstaff (neither of whom was present at the meeting at Bath) declined to serve on the Committee. The remaining two members of the Committee are of opinion that the question of a universal prime meridian is one that cannot usefully be considered by a Committee of the British Association at the present time.

Fifth Report of the Committee, consisting of Professor W. GRYLLS ADAMS (*Secretary*), Mr. W. LANT CARPENTER, Mr. C. H. CARPMAEL, Mr. W. H. M. CHRISTIE, Professor G. CHRYSTAL, Captain CREAK, Professor G. H. DARWIN, Mr. WILLIAM ELLIS, Sir J. H. LEFROY, Professor S. J. PERRY, Professor SCHUSTER, Professor Sir W. THOMSON, *and* Mr. G. M. WHIPPLE, *appointed for the purpose of considering the best means of Comparing and Reducing Magnetic Observations.*

THE Committee are able to report the establishment of regular magnetic observatories, where continuous photographic records of the magnetic elements are taken, at the United States Naval Observatory at Washington, and also at Los Angelos in California. The instruments used are of the Kew pattern, with the same time-scale, and the scale-coefficients for horizontal and vertical force instruments at Washington are very nearly those recommended by the Committee in their Third Report (1887), and which are in very near agreement with those at Vienna, St. Petersburg, and some other observatories.

The Committee report, further, that the plan proposed by them in their Third Report for the Comparison and Reduction of Magnetic Observations, has been adopted at the United States Naval Observatory at Washington, which is now prepared to take part in the general scheme of co-operation proposed by the Committee. Copies of the photographic registers of the three elements for April 21–30, May 1–31, and for June 1–30 have been forwarded to the Committee from Washington, with tables of scale and temperature coefficients. There are also forwarded two prints showing the reduction of the declination for the year 1888, by means of a graphic composite curve, made by tracing over one another with a pantograph the daily curves of the month, and then drawing a curve through them to show the monthly means.

There are also forwarded from Washington a set of prints showing the comparison of the disturbances of declination and horizontal force at Washington for ninety-nine days of 1888, and another set of prints showing the comparison of disturbances of declination on certain selected

days at Washington, Los Angelos, and Toronto, all reduced to the same time-scale of 30·6 mm. for two hours, *i.e.*, the time-scale of instruments of the Kew pattern.

Days in 1888 *selected by United States Naval Observatory for comparison of magnetic disturbances of Declination and Horizontal Force.*

January	7, 14, 15, 23, 24, 27.
February . . .	10, 11, 18, 19, 20, 21.
March	7, 8, 9, 10, 15, 16, 17, 18.
April	2, 3, 4, 5, 10, 11, 12, 13, 14, 30.
May	1, 6, 7, 8, 9, 10, 11, 20, 26.
June	2, 3, 4, 5, 6, 21, 22, 23, 24.
July	1, 2, 7, 8, 16, 19, 20, 21, 22, 27, 28.
August	2, 3, 15, 16, 17, 18, 19, 30.
September . . .	7, 8, 11, 12, 13, 14, 15, 19, 25, 26, 27.
October	5, 11, 19, 20, 30, 31.
November . . .	3, 4, 6, 16, 17, 18.
December . . .	5, 7, 13, 14, 23, 24.

The Committee are more than ever of the opinion expressed in their Third Report, ‘that the establishment of regular magnetic observatories at the Cape of Good Hope and in South America would materially contribute to our knowledge of terrestrial magnetism.’

The Committee consider that it would be desirable to publish annually in a collected form for certain selected days the curves of the three magnetic elements, *i.e.*, declination, horizontal force, and vertical force, taken at the different English and Colonial Magnetic Observatories, choosing for selection in 1888 the days for which the curves are published in the ‘Greenwich Observations.’

Report of the Committee, consisting of Professor ROBERTS-AUSTEN (*Chairman*), Mr. T. TURNER (*Secretary*), *and* Professor J. W LANGLEY, *appointed to consider the best method of establishing International Standards for the Analysis of Iron and Steel.* (*Drawn up by* Mr. THOMAS TURNER.)

THE Committee, which was appointed at the Bath meeting with the object above mentioned, requested the co-operation of several gentlemen of special experience in the analysis of iron and steel, and is at present constituted as follows:—Professor Roberts-Austen (Chairman), Sir F. Abel, Professor Langley, Mr. Edward Riley, Mr. G. J. Snelus, Mr. John Spiller, Professor Tilden, and Mr. Thomas Turner (Secretary).

The Committee have held several meetings during the year, and considerable correspondence has taken place in connection with the matters which it was appointed to consider. Ultimately the objects of the Committee were defined, and a number of suggestions were drawn up in order to assist in carrying out these objects. These suggestions were then published in various technical papers, before being finally revised, in order to allow persons interested to make any further suggestions which might appear advisable. After revision these proposals assumed the following form:—

Objects.

It is proposed that the Committee shall co-operate with other similar Committees in the more important iron-producing countries, in order to provide standard specimens of iron and steel, the chemical composition of which shall have been carefully determined. The specimens adopted as standards shall be entrusted to some recognised official authority, such as the Standards Department of the Board of Trade, and shall be used either for reference in the determination of the accuracy of any proposed method of analysis, or for controlling the results of analyses in any cases of importance, which may from time to time arise.

Suggestions.

1. Professor J. W. Langley, of the University of Michigan, U.S.A., to be requested to superintend the production of the samples; these to be prepared and preserved in accordance with the directions to be furnished by the Committee, and an equal portion of each sample to be forwarded to the several Secretaries of the respective Committees in the United Kingdom, America, France, Germany, and Sweden.

2. The specimens, which are eventually to be adopted as standards, to be supplied to not more than seven representative chemists of repute in each of the countries above mentioned, who shall be requested to analyse the specimens by any method or methods they may prefer.

3. In the event of the analyses giving results which in the opinion of the Committee may be regarded as sufficiently concordant, the means of the analytical results of each of the several constituents to be adopted as representing the composition of the standards. The report on the analytical results not to be issued before the various analysts to whom the samples have been submitted shall have had an opportunity of examining it. The standards to be hereafter distinguished only by letters or numbers.

4. The attention of the Committee to be for the present confined to five samples of steel, selected as containing as nearly as possible 1·3, 0·8, 0·4, 0·15, and 0·07 per cent. of total carbon, respectively. In addition to the determination of the amount of carbon present in each condition, the phosphorus, sulphur, silicon, manganese, and chromium also to be determined.

5. 200 kilos. of the samples selected for examination as standards to be prepared in all. This would give, after allowing sufficient for the required analyses, quite 5 kilos. of each standard for each of the five countries interested. Allowing say 10 grammes for each applicant who might desire to use the standards, this would permit of 500 appeals to each of the five standards in each country, or at least 12,500 appeals in all.

6. The metal of which the samples are to be produced to be cast in small ingots, special care being taken to prevent any irregularity of composition. After the removal of the outer skin the metal to be cut by a blunt tool in the form of thin shavings, and mixed as intimately as possible.

7. The samples thus prepared to be preserved in separate small quantities (say of 30 grammes each), which shall be hermetically sealed in glass tubes so as to prevent oxidation.

8. The samples to be analysed, in the United Kingdom, by Mr. A. H. Allen, Sheffield; Mr. W. Jenkins, Dowlais; Mr. G. S. Packer, Steel Company of Scotland; Mr. J. Pattinson, Newcastle-upon-Tyne; Mr. E. Riley, London; the Royal School of Mines; and Mr. J. E. Stead, Middlesbrough.

Progress of the Work.

Under date July 14, 1889, Professor Langley states that he has not as yet received a conclusive reply from the State Department at Washington to his application asking the Government to forward the samples through its consular agencies, so that they might reach their destination with the seals of the American Committee unbroken by the Custom House inspectors. The first four standards are ready to go as soon as word is received from Washington. They are packed in lead-lined hermetically sealed boxes, four for each country, and are enclosed by a larger wooden case, the whole weighing about 400 lb.

The material was prepared as nearly as possible in accordance with the directions of the British Association Committee. Ingots of crucible steel were selected from a lot of some twenty-five tons, which came nearest to the required carbon for the first three standards. The last, C=0·15, was too low to be made in a crucible, for after melting up a number of charges it was not found possible to get below 0·20 in the plumbago crucibles used. Professor Langley accordingly took a large billet of Open Hearth steel, and after forging had a piece weighing about 100 lbs. cut out of the centre.

The original weight of the ingots was 90 lbs., but after turning off the skin and allowing for the pipe and some inevitable loss in turning, not much over 50 lbs. could be recovered in drillings. This will cause the weight of the standards to be somewhat less than specified, but it seems as though there was no help for it, because to have attempted to make the quantity up from two ingots would have introduced metal of a slightly different carbon, and so brought about an objectionable lack of uniformity.

The metal was turned in a lathe at a very slow speed, and with a blunt tool. The whole time of turning was between three and four months.

In regard to pulverising the drillings as originally proposed, Professor Langley found it utterly impossible to do so by any means which would not introduce a notable quantity of foreign matter. Between chilled rolls the shavings only flattened. They were sifted through a 30-mesh sieve, and the fine material so obtained, which is small in quantity, is in a separate enclosure. The rest of the drillings are as nearly homogeneous as it is possible to make them, because they have been made from 'dead melted' stock formed at one heat from a single crucible.

The various committees are as follows:—Sweden, Professor Richard Akerman, Secretary; Germany, the Government Department of Tests; France, Mons. Ferd. Gautier, Secretary; England, the British Association Committee; United States, three members of the American Society of Civil Engineers, viz., William Metcalf, Thomas Rod, and A. E. Hunt; and three members of the faculty of the University of Michigan, viz., Professors J. W. Langley, A. B. Prescott, and M. E. Cooley.

The material for the standards and the mechanical work on them have been furnished by the Crescent Steel Works of Pittsburgh gratuitously,

because of the interest this firm has always shown in promoting the cause of scientific metallurgy.

Professor Langley further says:—'I can make the fifth standard, the 0·08 carbon suggested by your Committee, only it will take probably about two months. I will start upon it in a short time, as soon as I can make the right kind of stock, which will have to be Bessemer, for I can blow a heat as low as that without trouble.'

Within the last few days a letter has been received from Professor Langley as representing the University of Michigan, and from Mr. William Metcalf, on behalf of the American Society of Civil Engineers, stating that the samples have been despatched to each of the four countries previously mentioned (Great Britain, France, Germany, and Sweden). It is hoped that the analyses will be commenced almost immediately, and that by the next meeting of the Association the work may be in a forward condition.

Third Report of the Committee, consisting of Professors Tilden *and* Ramsay *and* Dr. Nicol (*Secretary*), *appointed for the purpose of investigating the Properties of Solutions.*

The Committee have to report that the work of investigating the solubility of salts in the solutions of other salts has been continued during the past year. Further experiments have also been made with the object of determining the law governing the solubility of various salts in alcohol and mixtures of alcohol and water of different strengths. In this way a vast amount of additional data has been gathered together, but the work of generalising from these has not progressed to the extent that it was hoped last year, and the Committee must therefore ask for re-appointment.

Third Report of the Committee, consisting of Professors Tilden, M'Leod, Pickering, Ramsay, *and* Young *and* Drs. A. R. Leeds *and* Nicol (*Secretary*), *appointed for the purpose of reporting on the Bibliography of Solution.*

The Committee have to report that considerable advance has been made in their work, with the following result:—

Journals Searched.

2. 'Memoirs of the American Academy of Arts and Sciences,' completed. 14 vols.
4. 'Annals of Philosophy,' completed. 28 vols.
5. 'Philosophical Magazine,' completed. 186 vols.
6. 'The Edinburgh Journal of Science.' Completed, 16 vols.
7. Nicholson's 'Journal,' completed. 41 vols.
14. 'Philosophical Transactions,' R.S.L.
15. Proceedings of above.
16. Philosophical Transactions,' R.S.E.
17. Proceedings of above.
20. Liebig's 'Annalen,' 80 vols.
21. Gilbert, Poggendorff, and Wiedemann, 'Annalen.' completed. 240 vols.
22. Schweigger's 'Journal,' completed. 69 vols.
25. Carl's 'Repertorium,' completed. 12 vols.
29. 'Annales de Chimie et Physique,' completed. 264 vols.

In all 950 volumes.

These journals were found to contain 675 papers on the subject of Solution, and these papers may be classified as follows :—

—	4	5	6	7	14	15	16	17	20	21	22	25	29	
A 1	—	2	—	—	1	—	—	1	2	5	—	1	5	17
2	—	6	—	—	—	—	—	1	4	1	—	—	2	14
B 1	4	25	—	—	1	1	—	—	32	14	18	—	33	128
2	—	—	—	—	—	—	—	—	—	2	—	—	3	5
3	4	14	—	—	1	—	1	—	2	7	2	—	9	40
C 1	1	16	1	—	1	—	—	1	6	19	3	1	15	64
2	—	4	—	—	1	—	1	—	—	5	—	1	8	20
3	—	2	—	—	—	—	—	—	2	5	—	—	10	19
4	—	5	—	—	—	1	—	—	2	26	2	2	11	49
5	—	4	—	—	—	1	—	—	1	12	—	2	9	29
6	—	11	1	—	2	1	—	—	3	15	1	2	5	41
7	—	2	—	—	1	—	—	—	—	5	—	1	1	10
8	—	—	—	—	—	—	—	—	8	1	—	1	1	11
9	—	—	—	—	—	—	—	—	1	—	—	—	—	1
10	—	2	—	—	—	1	—	—	—	1	—	—	—	4
D 1	—	3	—	—	2	—	—	—	2	20	—	—	6	33
2	—	7	—	—	1	—	—	1	8	5	—	—	30	52
Miscellaneous	2	40	3	—	2	2	—	1	1	48	6	—	33	138
	11	143	5	—	13	7	2	5	74	191	32	11	181	675

The Committee have to thank Miss Lloyd and Mr. A. J. Cooper, of Mason College, Birmingham, for their assistance in searching the 'Annales de Chimie et de Physique.' The Committee desire reappointment.

Report (Provisional) of a Committee, consisting of Professors M'LEOD *and* W. RAMSAY *and* Messrs. J. T. CUNDALL *and* W. A. SHENSTONE (*Secretary*), *appointed to investigate the Influence of the Silent Discharge of Electricity on Oxygen and other Gases.*

THE Committee was appointed to ascertain, if possible, the mode of action of the silent electric discharge in the ozonising of oxygen; to investigate the influence of such conditions as temperature and pressure on ozonification more exactly than has hitherto been done. Also to gain, if possible, further and more direct evidence concerning the molecular weight of ozone, and to study the action of the discharge on other gases.

In previous reports the preparation and storage of very pure oxygen has been described. It has been shown that very pure oxygen is readily converted into ozone, and that in some respects the properties of ozone when thoroughly dry differ from those of the same gas when it is contaminated with a trace of water vapour.

Although a considerable amount of work has been done since our last report was presented, various difficulties and several unavoidable accidents have prevented us from completing any part of our work. Immediately after the meeting at Manchester two members of the Committee proceeded to make quantitative experiments with specimens of pure oxygen. In these experiments known volumes of the gas at 0°C. and at known and nearly uniform pressures were submitted to the silent electric dis-

charge in apparatus so constructed that the whole mass of the gas was, practically, simultaneously exposed to the action of the discharge; hence the maximum effect was quickly arrived at. The amount of ozone formed was calculated (on the assumption that the density of its original ozone is 24) from the pressure at which the gas occupied unit volume before and after the action of the discharge. The discharge from a large Ruhmkorff coil was used.

The results obtained varied exceedingly. Under what appeared to be nearly identical conditions the yield of ozone was sometimes almost nominal, at others fairly good; whilst on one occasion nearly 20 per cent. of the oxygen employed appeared to have been converted into ozone. Subsequent experiments showed us that this was probably caused by the very variable action of the contact-maker of the coil, and it was therefore necessary to devise and construct a new contact-maker which should act with great regularity and be subject to perfect control. This involved considerable delay, and, unfortunately, just as the new apparatus was completed circumstances compelled us to suspend operations for many months.

Lately, however, work has been resumed, and the results since obtained justify the hope that our difficulties are now overcome. We hope, therefore, that at the next meeting of the Association we shall have made substantial progress with the investigation.

Since our last report was printed an interesting paper on ozone has been published by MM. Bichat at Guntz.[1] Some of their work bears upon the points we are investigating, and, as in some respects their results may seem not to offer us much encouragement, it is worth while to add that our method of experiment seems to us to be in certain respects better than that adopted by these investigators, and that consequently we still see good reason to hope for ultimate success.

Report of the Committee, consisting of Professors DEWAR, E. FRANKLAND, PERCY F. FRANKLAND (*Secretary*), *and* ODLING *and* MR. CROOKES, *appointed to confer with the Committee of the American Association for the Advancement of Science with a view of forming a uniform system of recording the results of Water Analysis.*

HAVING during the past two years given this matter our careful consideration, we beg herewith to submit the following report.

In order to ascertain the general feeling of chemists in this country on the subject, we have circulated the following series of questions amongst the leading water-analysts, upon whose co-operation the adoption of any uniform scheme must necessarily depend.

1. What is the system of recording the results of Water Analysis which you adopt?

(*a*) For the Mineral matters.
(*b*) For the Organic matters.
(*c*) For the Gaseous matters.

[1] *Comptes rendus*, 1888.

2. Have you any objections, and if so what are they, to the use of a Decimal system—such as parts per million, per 100,000, per 10,000, or per 1,000?

3. In recording the results of complete Analysis of the Mineral matters present in water, is it your custom to state the proportion of each individual Base and Acid as actually determined, or to combine the Bases and Acids so as to form salts?

4. Should it be your custom to combine the Bases and Acids, explain the principles by which you are guided in so combining them, and state what, in your opinion, are the advantages attaching to such combination.

5. If your present method of recording results is more or less influenced by special circumstances, such as the custom of professional Chemists generally, what other method of recording results would you yourself *select* as the most rational and the most convenient for universal adoption?

6. Would you support the adoption of the following method, recommended by the American Committee, of stating the constituents of a Mineral Water?—

> 'That the parts per thousand of each basic element, K, Na, Li, Ca, Mg, Fe'' (Fe_2), etc., be given, and of each acidic element, such as Cl, I, S, etc., that is combined directly with a basic element, or that may reasonably be supposed to be so combined, the rest of the acidic elements to be given in connection with all the oxygen of their salts, as usually written in our present empirical formulas, as SO_4, CO_3, PO_4, etc.'

From the answers we have received to the above questions, as well as from our own personal experience, we gather that there would be no reluctance on the part of British chemists to adopt a uniform and rational scheme, but for the great difficulty of rendering such a method of statement popularly understood. Thus the majority of analysts employ the '*grain-gallon*' system of statement, as being the one most intelligible to their clients, and this system undoubtedly possesses certain advantages in the case of analyses for technical purposes, in which the analytical figures have to be applied to large volumes of water which in this country are almost invariably measured in gallons.

We find, however, a general readiness on the part of most analysts to adopt a uniform and prescribed system only to be departed from in special cases, and we are of opinion that it would be impossible to secure more than such a qualified consent to any one system.

Although there is but little possibility of directly influencing the custom of professional chemists in their private practice, we are of opinion that it is of great importance to urge upon water-analysts the desirability of adopting some uniform system in the case of such analyses as are communicated to scientific societies or other learned bodies, and which are therefore calculated to have a circulation in countries where the imperial gallon is not recognised, and if such uniformity could be secured, there is but little doubt that the system would before long establish itself even in the case of analyses of a non-public character.

As regards the method of statement which would be most suitable for general use in such published analyses, we are of opinion—

(1) That it should be on the decimal system, preferably *parts per million* (mgrms. per litre), or *parts per* 100,000, as *parts per* 1,000 (grms. per

litre) would too frequently give rise to fractional results. The special advantages attaching to 'parts per 100,000' are that the figures for mineral waters are not inconveniently large, nor those for potable waters inconveniently small, whilst their conversion into grains per gallon is a very simple operation.

We cannot agree with the American Committee that different scales should be adopted for mineral and potable waters respectively, for such a dual system must, in our opinion, inevitably lead to confusion.

(2) We attribute the greatest importance above all to the clear statement, in every case, of the actual determinations made, and that all results derived by calculation should be sharply distinguished from those obtained by direct determination.

Thus we view with particular disapprobation the statement of the mineral ingredients combined as *salts*, unless accompanied by a clear account of the analytical data upon which this statement is founded.

(3) As regards the statement of the mineral ingredients, we have considered the method suggested by the American Committee, and which consists in recording the proportion of each metallic element (K, Na, Li, Ca, Mg, Fe″, Fe_2, &c.), as well as that of each electronegative element (F, Cl, Br, I, S, &c.) contained in binary compounds, whilst in the case of oxy-compounds the electronegative element is given as combined with the whole of the oxygen (SO_4, PO_4, NO_3, CO_3, &c.), and we are of opinion that this arrangement is decidedly the most convenient for all purposes of calculation, although the absence of any recognised names for these acid-groups, as well as the prevailing custom of estimating the metallic elements in the condition of bases (K_2O, Na_2O, CaO, &c.) are undoubted objections to this system.

(4) That the amount of dissolved gases (O, N, CO_2, SH_2, &c.) may be most conveniently expressed either in cubic centimetres per litre or in volumes of gas per 100 volumes of water, the latter being the more general practice in this country.

The system of statement which we wish to recommend will be most readily understood from the following form for a complete analysis:—

RESULTS OF ANALYSIS EXPRESSED IN PARTS PER 100,000.

Potable Water:—

Total solid matters (a) In suspension. ________

Total solid matters (b) In solution. ________

Organic carbon. ________

Organic nitrogen. ________

Oxygen consumed, as indicated by decolouration of permanganate. ________

Ammonia expelled on boiling with sodium carbonate. ________

Ammonia expelled on boiling with alkaline permanganate. ________

Nitrogen as nitrates and nitrites. ________

Chlorine. ________

Potable Water (contd.):—

Hardness
- Temporary.
- Permanent.
- Total.

Mineral Water:—

Carbonate of lime ($CaCO_3$).

Carbonate of magnesia ($MgCO_3$).

Carbonate of soda (Na_2CO_3) (calculated from residual alkalinity after boiling and filtering off precipitated $CaCO_3$ and $MgCO_3$).

Total calcium (Ca).

Total magnesium (Mg).

Total potassium (K).

Total sodium (Na).

Iron (ferrous) (Fe'').

Iron (ferric) (Fe_2).

Sulphuric radical (SO_4).

Nitric radical (NO_3).

Nitrous radical (NO_2).

Phosphoric radical (PO_4).

Silicic radical (SiO_3).

Chlorine (Cl).

Bromine (Br).

Iodine (I).

Sulphur as Sulphide (S).

DISSOLVED GASES.

Cubic centimetres of Gas at 0° *C., and* 760 *millimetres in* 1 *litre of water.*

Carbonic anhydride (CO_2).

Oxygen (O).

Nitrogen (N).

Sulphuretted hydrogen (H_2S).

Second Report of the Committee, consisting of Dr. RUSSELL (*Chairman*), Dr. A. RICHARDSON (*Secretary*), Captain ABNEY, *and* Professors W. N. HARTLEY *and* W. RAMSAY, *appointed for the investigation of the action of Light on the Hydracids of the Halogens in presence of Oxygen.* (*Drawn up by* Dr. A. RICHARDSON.)

AN extended series of experiments has been made during the past year on the following lines:—

Solutions of chlorine water were mixed with equal volumes of dilute hydrochloric acid of strengths varying between ·029 per cent. and 1·44 per cent.; these solutions were exposed in sealed tubes to sunlight.

After seven days (August 17 to August 24) the free and combined chlorine contained in the liquids was estimated. A glance at the following table will show that the addition of even a small percentage of hydrochloric acid exerts a very material influence on the stability of the chlorine water. A parallel series of experiments was made with hydrochloric acid of the same strength as that used in the previous experiments, free chlorine being absent; these solutions were exposed in presence of free oxygen for a similar period. It was found that no chlorine was liberated from the acid, but that on increasing the strength of the acid to 15 per cent. a trace of chlorine was set free, whilst a 30 per cent. solution gave 1·01 per cent. free chlorine. On comparing these two sets of experiments it is seen that the oxygen liberated by the decomposition of water by chlorine decomposes hydrochloric acid present in the solution, whereby free chlorine is restored to the liquid, although the same strength of acid is stable under the influence of light in free oxygen.

Hydrochloric Acid and Chlorine Water exposed to Light for seven days, August 17–24.

No.	Grammes free Cl taken	Grammes HCl added	Per cent. HCl in Solution	Grammes Cl as HCl found	Grammes free Cl found	Per cent. combined Cl	Per cent. free Cl
1	0·5689	0·0434	0·02899	0·5556	0·0133	97·66	2·34
2	0·5419	0·4343	0·2899	0·4736	0·0683	87·39	12·61
3	0·5218	0·6514	0·4009	0·3727	0·1491	71·42	28·57
4	0·5809	0·8812	0·5874	0·3529	0·2280	60·75	39·25
5	0·5807	1·0853	0·7239	0·2399	0·3408	41·29	58·71
6	0·5659	1·7374	1·1583	0·0689	0·4970	12·18	87·82
7	0·5830	2·1717	1·4478	0·0265	0·55659	4·53	95·47

Further, it was noticed that the rate at which chlorine water was decomposed was unaltered, whether oxygen or an inert gas like carbon dioxide occupied the space above the solution.

The action of ozone on gaseous hydrogen chloride has been studied. Tubes of about 300 mms. in length were filled with a mixture of equal parts of hydrogen chloride and oxygen containing ozone, and exposed to light.

A rough estimate of the relative rates of decomposition of the gas in the different tubes was obtained by observing the colour of the gas; as seen by looking through the length of the tube against a white back-

ground, minute quantities of chlorine liberated gave a green tinge to the gas. The following is the order in time in which a green tint was first observed in the different tubes:—

After 1 day moist ozone and moist hydrogen chloride.
„ 3 days „ oxygen „ „ „
„ 5 „ partially dry ozone, partially dry hydrogen chloride.
„ 96 „ „ „ oxygen „ „ „ „

Ozone and hydrogen chloride were dried over phosphorus pentoxide and exposed to light for 96 days (May 24 to August 28); the gas in the tube was then drawn through a solution of potassium iodide, but no trace of free chlorine could be detected.

Similar tubes containing dry and moist hydrogen chloride and ozone were kept in the dark for 96 days. After that time no trace of green colour could be detected in the tubes, and on the addition of solution of potassium iodide to the contents of the tube, chlorine and ozone were proved to be absent. Although gaseous hydrogen chloride is not decomposed by ozone in the dark, yet it was found that when ozone was allowed to pass through a 30 per cent. solution of the acid (in the dark) a decided smell of chlorine was observed, especially after allowing the solution to stand for some time in a stoppered bottle. A solution of hydrogen dioxide added to a 15 per cent. solution of hydrochloric acid in the dark also liberated chlorine, which was at once detected by the smell. Experiments in this direction are still being made.

In a previous report it has been pointed out that dry hydrogen chloride and dry oxygen are unchanged even after long exposure to sunlight, but that the presence of liquid water very much hastens the decomposition of the acid, the oxidation being most rapid when water is present sufficient to form a saturated solution of the gas.

In this, as in many other cases, it is the combined influence of water and oxygen in presence of sunlight which causes oxidation, and in seeking for an explanation of the part played by water in promoting decomposition the possibility of the formation of hydrogen dioxide suggested itself. In order to decide this point a very large number of experiments have been made, only a few of which need be quoted. It is quite obvious that in the absence of any substance upon which the peroxide can act, minute quantities which may be formed in pure water will readily be decomposed and so escape detection. In the first experiments varying quantities of pure ether were added to the water, as it is known that the presence of this substance increases the stability of the peroxide without itself being acted upon.

100 ccs. of water were mixed with 25 ccs. of pure ether; this liquid was exposed to light in an atmosphere of oxygen for 66 days (Dec. 10 to Feb. 4). After this time some of the ether was shaken with a solution of potassium bichromate, when the presence of hydrogen peroxide was at once shown by the decided blue colour imparted to the ether. Tubes containing pure ether and water were exposed to sunlight in presence of oxygen from Feb. 7 to May 16 (98 days): these solutions after exposure readily liberated iodine from a 5 per cent. solution of potassium iodide; this was estimated by $\frac{n}{1000}$ solution of sodium thiosulphate. After addition of the iodide, the solution was shaken and allowed to stand in the dark for some hours before titration with the thiosulphate.

Before giving the results of these experiments it may be mentioned

that the ether used was very carefully purified, and when tested by the iodoform reaction it gave only a very minute trace of alcohol; the oxygen used was purified by passing through solutions of potassium iodide, sodium hydrate, and water. The mixture of ether and water was tested in one experiment after exposure; it was found to be neutral to litmus, and contained only a trace of alcohol, whilst the gas above the liquid was free from carbon dioxide; the ethereal solution, however, freely liberated iodine from potassium iodide.

The results of seven experiments are given in the following table:—

No.	ccs. H_2O	ccs. $(C_2H_5)_2O$	ccs. O	ccs. $\frac{n}{1000}$ $Na_2S_2O_3$ required	Equivalent in grms. I.	Equivalent in grms. H_2O_2
1	100	5	75	60·0	0·00765	0·0010
2	100	15	80	104·0	0·01326	0·00176
3	80	30	70	184·1	0·02347	0·00313
4	Water vapour contained in O saturated at 0°	5	1,000	128·0	0·01632	0·002176
5	Water vapour in O saturated at 0°	3 entirely converted into gas	1,312	—	Absent	Absent
6	100	15	O replaced by CO_2	—	Absent	Absent
7	100 exposed to heating effects of sunlight only, tube wrapped in tinfoil	15	65	—	Absent	Absent

It will be seen from these experiments that the amount of hydrogen peroxide which is formed is dependent on the proportion of ether to water present. Thus in No. 1 there was no excess of liquid ether, but it was completely dissolved in the water; again, when the water and ether are present as gas no peroxide is formed (see No. 5); this is also the case when oxygen is absent (No. 6), and when the solutions are exposed to the same temperature changes in the dark in an atmosphere of oxygen.

The next experiments were made with water and oxygen, the ether being omitted.

Two bottles of 900 ccs. capacity were charged with 500 ccs. of water containing 2·5 per cent. of pure sulphuric acid; the space above the water was filled with oxygen. In one experiment the exposure was made in sunlight, whilst in the other case the liquid was exposed to rays of low refrangibility only, by allowing the light to pass through a cell containing a strong solution of potassium bichromate.

The exposure was started on July 28, and 50 ccs. of the solutions were tested from time to time with $\frac{n}{1000}$ potassium permanganate. In each case the number of ccs. of the permanganate required to produce a pink tint in 50 ccs. of pure water was determined, and deducted from that required for the same volume of the solution. The following table gives the results of these analyses, the terms 'red' and 'white' being used to distinguish between the two sets of experiments. In Nos. 2 and 4 the analyses were made after prolonged periods of cloudy weather, whilst in 7 and 8 the solutions had been exposed to bright sunshine. Nos. 5 and 6

show that, whatever the agent may be which decolourises the permanganate, it readily becomes inactive on standing in the dark, but that it is again formed by exposing the liquid to light; this process can be repeated indefinitely. In these experiments the temperature was kept below 25°C. Another experiment was made to determine to what extent evaporation and condensation of the liquid due to changes in temperature bring about the formation of the peroxide. Acidified water was exposed in two flasks; in one case the flask was rendered impervious to light by a covering of opaque paper, whilst the other flask was exposed to light. After one week's exposure to bright sunshine (Aug. 20 to Aug. 27) the liquid was tested with permanganate, when it was found that 50 ccs. water from the flask in the dark registered 1 cc. permanganate (50 ccs. pure acidified water required 1 cc. permanganate), showing absence of peroxide of hydrogen. 50 ccs. of water from the exposed flask registered 2·4 ccs. permanganate, subtracting 1 cc. for pure water = 1·4 cc. due to the peroxide =·00047 per cent.

Table showing the Action of Light on Water and Oxygen.
Exposure July 28 *to August* 30.

No.	Nature of the Light	Exposure	ccs. $KMnO_4$ for 50 ccs. of Solution	ccs. $KMnO_4$ for 50 ccs. of pure H_2O	Corrected number of ccs.	Equivalent in grms. of H_2O_2	Percentage of H_2O_2
1	Red	23 days . .	1·4	1·2	0·2	0·000034	0·000068
2	White	23 days . .	2·8	1·2	1·6	0·000272	0·000544
3	Red	56 days . .	1·0	0·8	0·2	0·000034	0·000068
4	White	56 days . .	2·5	0·8	1·7	0·000289	0·000578
5	White	Kept 2 days in the dark	1·8	0·9	1·1	0·000187	0·000374
6	White	After 6 days in the dark	1·0	1·0	—	—	—
7	White	After 4 days' sunshine, Aug. 20–24	3·0	1·0	2·0	0·00034	0·00068
8	White	After 10 days' sunshine, till Aug. 30	6·9	1·3	5·6	0·000951	0·00190
9	Red	Aug. 30 . .	1·6	1·3	0·3	0·000051	0·000102

Dry and moist oxygen were exposed to light, but no trace of ozone or hydrogen peroxide was detected.

These experiments seem to show that hydrogen peroxide is formed when oxygen and liquid water are exposed to sunshine, and that the rays of high refrangibility are influential in bringing this change about.

The influence of moisture in bringing about the oxidation of hydrogen chloride is now easily explained, for it seems probable that when a saturated solution of the chloride is exposed to light in presence of oxygen, hydrogen dioxide is first formed, and it is this substance which decomposes the hydrogen chloride. Further, the oxidation of the sulphides and of certain pigments by light is explained, though no clue is afforded to the explanation of reductions by light, since in many instances this takes place in dry air.

Numerous experiments are being made in other directions, but these are not sufficiently advanced for publication.

Seventh Report of the Committee, consisting of Mr. R. ETHERIDGE, Dr. H. WOODWARD, *and* Professor T. RUPERT JONES (*Secretary*), *on the Fossil Phyllopoda of the Palæozoic Rocks.*

I. *Aristozoe* and *Callizoe.*
II. *Bactropus.*
III. *Tropidocaris.*
IV. *Echinocaris.*
V. *Nothozoe.*
VI. *Protocaris.*
VII. *Ceratiocaris.*
  1. *Patula*, Ludlow.
  2. *Patula*, Dudley.
  3. *Pusilla.*
  4. *Cenomanensis.*
  5. *Grandis.*
VIII. *Caridolites* (*Ceratiocaris?*).
IX. *Dithyrocaris.*
X. *Lingulocaris.*
XI. *Discinocaris.*
XII. *Estheria* and *Estheriella.*
  1. *Wenjukoff's.*
  2. *Ludwig's.*
  3. *Kratow's.*
  4. *Weiss's.*
  5. *Scotch.*
XIII. *Ribeiria.*
XIV. *Proricaris.*

I. *Aristozoe* and *Callizoe.*—Mr. C. D. Walcott, of the U. S. Geol. Survey, refers two Lower-Cambrian fossils, from the Olenellus-zone of the eastern part of the State of New York, to *Aristozoe*, namely, *A. Troyensis* (Ford), and *A. rotundata*, Walcott. 'Amer. Journ. Science,' ser. 3, vol. xxxiv. (1887), p. 193, pl. 1, figs. 8 and 9. Fig. 8 more nearly approaches Barrande's *Callizoe* in appearance.

To this closely allied genus, *Callizoe*, Barr., belongs Richter's *Beyrichia armata*, 'Zeitsch. d. g. Ges.,' vol. xv., 1863, p. 672, pl. 19, figs. 16–18; see 'Geol. Mag.,' 1881, p. 342. This is from the Upper Silurian Tentaculite-beds of Thuringia.

Linnarson's *Leperditia primordalis*, 'Kongl. Svensk. Vet.-Akad. Handlingar,' vol. viii., 1869, p. 84, pl. 2, figs. 65, 66, from the Olenus-Schist of Westergötland, belongs to the same genus; and a closely-allied species of *Callizoe* is represented in Angelin's unpublished 'Plate A' of Scandinavian Entomostraca, figs. 9, 9*a*, 9*b*, 9*c*.

II. *Bactropus.*—The *Bactropus* referred to in our Sixth Report on the Fossil Phyllopoda [1] (September, 1888) has been figured and described by the Rev. G. F. Whidborne, F.G.S., in the First Part of 'A Monograph of the Devonian Fauna of the South of England,' Palæontographical Society, 1889, p. 43, pl. 4, fig. 21, as *B. decoratus*, a segment of the abdomen of an *Aristozoe.*

III. *Tropidocaris.*—In the same Monograph, p. 44, pl. 4, figs. 20 *a*, *b*, Mr. Whidborne also describes and figures a fragment of a phyllocaridal cephalothorax, probably belonging to the genus *Tropidocaris*, Beecher.

IV. *Echinocaris.*—Another and more perfect Phyllocaridal specimen has been discovered in Devonshire, namely one half (left valve) and rather more of the cephalothorax of an *Echinocaris*, by Mr. Dufton in the leaden-blue shales of the *Lingula-squamiformis* beds in a quarry near Sloly, close to the three-milestone on the Barnstaple and Ilfracombe road. The shales, here interstratified with very micaceous frilled sandstones, belong to the Cucullæa-zone of the Marwood Beds. This *Echinocaris*, first recognised by the Rev. G. F. Whidborne, is related to *E. socialis*, Beecher,[2] but the

[1] *Report Brit. Assoc.* (for 1888), 1889, p. 175.
[2] *Second Geol. Surv. Pennsylvania*, vol. PPP, 1884, p. 10, pl. 1, figs. 1–12; and Hall's *Report Geol. N.Y.*, *Palæont.*, vol. vii., 1888, p. 174, pl. 20, figs. 1–12.

carapace-valve is rounder. This unique specimen belongs to the Woodwardian Museum, Cambridge.

V. *Nothozoe.*—If *Nothozoe*, Barrande, be reckoned among the Phyllopoda,[1] R. P. Whitfield's *Nothozoe? Vermontana* should be noticed. It is nearly ovate in shape, $\frac{3}{4} \times \frac{1}{2}$ inch in dimensions. From the Potsdam sandstone of Vermont, U.S. See 'Bullet. Amer. Mus. Nat. Hist.' vol i., No. 5, p. 144, figs. 14 and 15 (1883?).

VI. *Protocaris.*—*Protocaris Marshi*, Walcott, 'Bullet. U.S. Geol. Survey,' No. 10 (1884–5), p. 50, pl. 10; No. 30 (1886), pp. 147, 148, pl. 15, fig. 1, appears as a compressed Apudiform organism, with a flattened, subquadrate, obscure cephalothorax, and a tapering body or abdomen of '30 narrow segments, a large terminal segment or telson, with two rather strong caudal or terminal spines.' 'Total length, 42 mm.; length of carapace, 21 mm.; width, 26 mm.; length of body, 15 mm., exclusive of caudal spines; width of body where it passes beneath the carapace, 10 mm.; at telson, 4 mm.' From the 'Middle Cambrian, Georgia Formation; Parker's farm, town of Georgia, Vermont.'

VII. *Ceratiocaris.*—1. In the 'British Association Report for 1855' (1856), Trans. Sections, (Part II.), pp. 98, 99, the late Rev. W. S. Symonds recorded the discovery by Mr. Lightbody in the Upper-Ludlow Shales on the banks of the Teme, near Ludlow, of a fine specimen of the caudal trifid appendage of a Phyllopodal Crustacean, and in the 'Edinb. New Philos. Journ.,' new series, vol. ii. (1855), p. 404, pl. 8, he gave a descriptive note, together with a careful drawing made by Mrs. Humphrey Salwey. We have not been able to trace the ultimate disposition of this interesting fossil. If the drawing gives the natural size, the specimen might be said to be a gigantic form of *Ceratiocaris patula*, T. R. J. and H. W., 'Monogr. Brit. Pal. Phylloc.' 1888, p. 46, pl. 11, fig. 11.

2. The British Museum (Natural History) has obtained the trifid caudal appendage of a small *Ceratiocaris* (I 1007) from the Wenlock Limestone of Dudley, which also resembles *C. patula.*

3. A new species of *Ceratiocaris* has been published in the 'Trans. Royal Society of Canada,' Section IV., 1888. In his memoir 'On some remarkable Organisms of the Silurian and Devonian Rocks in Southern New Brunswick,' p. 56, pl. 4, fig. 9, Mr. G. F. Matthew gives the following:—

Ceratiocaris pusilla, n. sp.—A small, elongate, and delicately shaped *Ceratiocaris*, carapace 15 mm., and altogether about 30 mm. long, 5 mm. wide. 'This little species occurs in myriads in the black fissile shales of Division 2 of the Silurian succession at Cunningham Brook, Westfield Station, N.B.' These strata are regarded as being of the age of the Mayhill Sandstone. In the same black shale Mr. Matthew has found the fossil fish *Diplaspis*, n. gen., *op. cit.*, pp. 49–55.

4. A Lower-Silurian (Ordovician) species of *Ceratiocaris* (*C. Cenomanensis*, Tromelin) is referred to in the Report of the 'Assoc. Française pour l'Avancement des Sciences; Compte rendu de la 4[me] Session, Nantes, 1875' (8vo. Paris, 1876), p. 623, as occurring in the 'Calcaires ampéliteux' of Lusanger, and in the 'Bullet. Soc. Géol. France,' sér. 3, vol. iv. 1876, in Table B, as in the same limestone at Chamiré-en-Charnie, Dep. Sarthe. M. Paul Lebesconte, of Rennes, has obligingly given us the opportunity of examining a large series of the palæozoic fossils from

[1] Third Report (for 1885), pp. 358, 359.

Sarthe, Ille-et-Vilaine, and Mayenne, but only one small Ceratiocarid fragment (in the Schiste ardoisier inférieur, below the Grès de May), from Laillé, was met with, and nothing corresponding to what M. Gaston Le Goarant de Tromelin described as *C. Cenomanensis* in the 'Lettre sur le terrain silurien de la Sarthe,' addressed to M. Guillier by M. de Tromelin, 'Bullet. Soc. agriculture, sciences et arts de la Sarthe,' vol. xxii. (1874), pp. 582–590. This work being rather rare, we transcribe the original description (p. 586): 'Cette espèce se distingue de *C. Bohemicus* et *C. inæqualis* en ce que les trois branches du gouvernail sont à peu près lisses et n'offrent que quelques faibles rainures longitudinales. La branche principale est plus robuste que les branches secondaires; toutes trois, assez fortes à leur naissance, se réduisent rapidement, et ne paraissent pas d'avoir dépassé la longueur de 30 millimètres; elles sont un peu aplaties dans le sens latéral. Dans tous nos exemplaires elles sont inclinées à 45 degrés par rapport au dernier segment du corps. Celui-ci semble sub-cylindrique, et l'empreinte du test offre quelques stries longitudinales sans continuité. La forme la plus analogue est *C. Scharyi*, Barr., de Bohême, dont le gouvernail est imparfaitement connu. L'espèce portugaise figurée par Sharpe sous le nom de *Dithyrocaris longicauda* [1] et la nôtre pourraient bien être identiques.' No figure is given.

M. de Tromelin also determined *Ceratiocaris Bohemica*, Barr., from Saint-Sauveur (Manche), and *C. inæqualis*, Barr., from Chamiré (Sarthe), *op. cit.* p. 585.

5. The *Ceratiocaris grandis*, described and figured in outline by Dr. Julius Pohlman in the 'Bullet. Buffalo Soc. Nat. Hist.' vol. iv. 1881, p. 19, fig. 5, appears to have been a symmetrically oval plate, with subacute ends, once convex, but now flattened and marked by a crack on one side, reaching rather more than half-way across. Its relationship is obscure. In size, if the figure be one-fourth more than the natural size ('$\times\frac{1}{4}$'), the specimen is really about $2 \times 1\frac{1}{2}$ inches in dimensions.

VIII. *Caridolites* (*Ceratiocaris*?).—In the 'Proc. Royal Soc.,' May 8, 1873, p. 289, Dr. H. A. Nicholson, in his paper on annelid marks, noted some fossil 'tracks apparently produced by crustaceans belonging to the genus *Ceratiocaris*, and for which he proposes the generic name of *Caridolites*'; distinguishing them as *C. Wilsoni* at p. 290. See also 'Geol. Mag.' 1873, pp. 309, 310. The author has very kindly enabled us to study some of the marks referred provisionally to *Ceratiocaris* in a dark-grey, finely micaceous, laminated, hard mudstone (Upper Silurian) from Grieston-on-Tweed, in Peeblesshire. The marks are very narrow, some concave (furrows), some convex (casts); some nearly parallel, others differing in direction, and nearly all branching off at various angles to apparently tapering terminations. Their origin is obscure.

IX. *Dithyrocaris*.—M. Lebesconte's collection, above mentioned, comprises two specimens of *Dithyrocaris*, one from Coësmes (Ille-et-Vilaine), and one from Renazé (Mayenne), both in the 'Schiste ardoisier supérieur (Faune 2[1e], Barrande),' above the Grès de May.

X. *Lingulocaris*.—Another interesting specimen in M. Lebesconte's collection is from the 'Schiste ardoisier inférieur (Faune 2[de])' of Angers (Maine & Loire), and very closely resembles *Lingulocaris Salteriana*, J. and W., shown by fig. 6, at p. 179 of our Sixth Report

[1] This is described in detail in our *Monogr. Brit. Pal. Phyll.*, p. 61, pl. 11, fig. 16. Its generic position is still uncertain.

(for 1888). Unfortunately it is badly preserved and not quite perfect.

XI. *Discinocaris.—Discinocaris gigas*, H. W., was referred to in our Second Report (for 1884), as having possibly a diameter of seven inches. Mr. James Dairon, F.G.S., of Glasgow, has sent us a careful sketch of a fine specimen of this *Discinocaris*, found by Mr. William Brown (of Birkhill, Dumfriesshire) in the graptolitic shales of Dobbs Linn, Moffat. It has somewhat the outline of the bottom of a horse's hoof, boldly curved on one edge, and broadly indented with a shallow triangle on the other. It has been much more convex than it is now, being somewhat crushed, and radiately cracked towards the curved margin. It measures about 3 inches (73 centimètres) transversely from one side of the curve to the other, and about 2 inches (5½ centimètres) from the apex of the triangular indentation to the opposite edge.

XII. *Estheria* and *Estheriella.*—1. In his memoir on the Fauna of the Devonian system in North-western and Central Russia (in Russ and German), 8vo., St. Petersburg, 1886, pp. 223, 224, P. N. Wenjukoff gives an account of the *Estheria membranacea* (Pacht) and its synonymy.

2. Ludwig's *Cyclas obuncula* in his memoir on 'The Freshwater Shells of the Coal-formation of the Ural,' 1861, in the 'Palæontographica,' vol. x., p. 23, pl. 3, figs. 3 and 3A, is probably an *Estheria*,[1] from the Permian or Permio-Carboniferous bituminous marl with *Anthracomya* (?) *Uralica* (Ldwg.) and *A.* (?) *obstipa* (Ldwg.), on the left bank of the Uswa, near Nischni Parogi, in the Government of Perm. It is referred to, with a wrong reference, by P. Kratow in the 'Mémoires du Comité Géologique,' St. Petersburg, 1888, vol. vi., Lief. 2, p. 510.

3. In his 'Geologische Forschungen am westlichen Ural-Abhange in den Gebieten von Tscherdyn und Ssolikamsk'; 'Mémoires du Comité Géologique'; St. Petersburg, vol. vi., Lief. 2, 4to., 1888, Herr P. Kratow describes and figures the following Palæozoic Phyllopods:—*Estheria subconcentrica*, nov., pl. 2, fig. 26, pp. 469 and 556; *Estheriella trapezoidalis*, nov., fig. 27, pp. 469 and 557; *Estheriella oblonga*, nov., fig. 28, pp. 470 and 557, from the Permio-Carboniferous formation of the west side of the Ural (Districts of Tscherden and Ssolikamsk); and from the Permian formation of the same region: *Estheria*, sp., pl. 2, fig. 25, pp. 510 and 559; *Estheria*, sp., pp. 511 and 559.

4. In 1875 Herr Weiss described *Estheriella* as being like *Estheria*, but bearing radial riblets (6–12 in number), 'Zeitsch. d. G. Gesell.,' vol. xxvii., 1875, pp. 711, 712. *Estheriella lineata* and *costata* are his types, both from the Lower Buntersandstein of Durrenberg, Saxony. See also Zittel's 'Handbuch der Palæontologie,' &c., p. 560, vol. i., part 2, No. 4 (vol i., No. 8), 1885.

5. Figures and descriptions of *Estheria punctatella*, Jones, from the Glasgow Coal-field, and some allied forms, including an *Estheriella* from the same Carboniferous series, are being prepared for publication.

XIII. *Ribeiria.*—In the 'Geol. Mag.', vol. i. (1864), p. 12, Mr. Salter stated that *Ribeiria pholadiformis*, Sharpe, 'Quart. Journ. Geol. Soc.', vol. ix., pp. 157–8, pl. 9, fig. 17, may very possibly be a bivalved crustacean belonging to the same group (Phyllopod) as that to which his *Myocaris*[2] ('Geol. Mag.', *loc. cit.*), p. 11, belongs.

[1] For other Palæozoic *Estheriæ*, see our Fifth Report (for 1887), pp. 68, 69, and Sixth Report (for 1888), p. 181.

[2] Catalogued as a Phyllopodous Crustacean in our First Report (1883), p. 217.

After describing *Myocaris lutraria* as a bivalve crustacean related to *Ceratiocaris*, in the 'Quart. Journ. Geol. Soc.,' vol. xx. (1864), p. 292, Mr. Salter stated with regard to *Ribeiria*, that 'the strong internal sub-cardinal ridge, marking the position of the cervical furrow, leads me to suspect that *Ribeiria*, a Lower-Silurian genus which has not yet found its place, may be a cognate form. A univalve carapace would be nothing remarkable among the allies of *Nebalia*, but is very puzzling if referred to Lamellibranch, while the whole aspect is unlike that of any of the Calyptræiform shells. I think that we may have here the true affinity, but the suggestion is only given to induce research. The strong muscular scar behind the beak is against it.'

Salter, however, seems to have regarded *Ribeiria* as a mollusc in 1866, 'Mem. Geol. Survey,' vol. iii. p. 346, where his *Ribeiria complanata* (pl. 11B, fig. 16), from the Lower Llandeilo of Shropshire, is described; but with the words 'There is some uncertainty as to the group to which this curious fossil belongs.' In 'Siluria,' also, in the '4th' (really the 3rd) Edition, 1867, at pp. 48 and 49, it seems to be regarded as a mollusc: but at p. 521 its molluscan position has a note of interrogation. Baily ('Figures of Characteristics of British Fossils,' Part 1, 1867) copied Salter's figure and placed it in the Conchifera, p. 21, pl. 8, fig. 9.

E. Billings, in 'Canad. Geol. Surv., Pal. Foss.', vol. i. (1865), referring some fossils to Sharpe's *Ribeiria*, but of uncertain alliance ('*incertæ sedis*') and, if subgenerically distinct, to be provisionally named *Ribeirina*, regarded them as being possibly byssus-bearing molluscs. These were *Ribeiria* (?) *calcifera*, p. 340, fig. 326, and *R.* (?) *longiuscula*, p. 340, fig. 237.

In Dr. Bigsby's 'Thesaurus Siluricus,' 1868, p. 141, *Ribeiria*, Sharpe, 1853, is catalogued as a Dimyarian Mollusc, with the following species:—

calcifera } Billings. Calciferous Sandstone; Grenville, Canada.
longiuscula }
complanata, Salter. Lower Llandeilo; Salop.
conformis } Salter. Budleigh-Salterton pebbles.
magnifica }
pholadiformis, Sharpe. Fauna D d, 1, 4, 5, Caradoc; Portugal, Spain, Bohemia.

At page 168 *Ribeiria* is grouped with the Gasteropoda, and *R. Sharpei*, Barrande, D d, 3, Bohemia is added.

Under the heading of 'Phyllopodes' belonging to the Grès de May (Calvados) M. G. de Tromelin has cited two species of *Ribeiria*. In the 'Bullet. Soc. Linn. Normandie,' ser. 3, vol. i., 1887, p. 35 and p. 74, M. G. de Tromelin stated that Mr. Salter had named but not described two species of *Ribeiria* from Mr. Vicary's collection of the pebbles from Budleigh-Salterton, and which had been found also in the May Sandstone of Normandy, namely:—1. *R. conformis*, Salter, Bigsby, 'Thes. Silur.' p. 141 (1868); Tromelin and Lebesconte, 'Bullet. Soc. Géol. France,' ser. 3, vol. iv., table D, No. 43, 1876. *R. Bussacensis* [*pholadiformis*], Sharpe, Q. J. G. S., vol. ix. pl. 9, fig. 17 (1853). From May and Jurques (Calvados). 2. *R. magnifica*, Salter, Bigsby, *op. cit.* (1868); Trom. and Lebesconte, No. 42 (1876). From Compandré (Calvados).

In Nicholson's 'Manual of Palæontology,' 2nd edit. 1879, vol. i. p. 351, the zoological position of *Ribeiria* is left doubtful.

In the 'Bullet. Amer. Mus. Nat. Hist.' vol. i. No. 8 (1886), pp. 343, 344, Prof. R. P. Whitfield describes two species of *Ribeiria* (*R. compressa*, pl. 33, figs. 3–5, and *R. ventricosa*, figs. 1 and 2), and refers them with some doubt to the *Ceratiocaridæ* (*Phyllocaridæ*, Packard), as having the shell bent double, but not hinged.

In R. Etheridge's 'Catal. Palæoz. Fossils,' 1888, this genus is placed with the Conchifera (Anatinidæ) at p. 109, and with the Gasteropoda [Calyptræidæ ?] at p. 549, as indicated by Barrande also.

[We do not know of any Phyllocarid having the internal structure which is shown by the casts of *Ribeiria*.]

XIV. *Proricaris.—Proricaris MacHenrici*,[1] Baily, referred to in our First Report [2] (for 1883) as '*Protocaris*, Baily, 1872 (not well known),' has now been carefully examined by us. The several specimens from the Upper Old-Red-Sandstone of Kiltorcan, co. Kilkenny, on which the genus and species were established by the late Mr. W. H. Baily, have been kindly lent to us, by favour of Dr. E. Hull, Director of the Geological Survey of Ireland.

Mr. Baily had courteously given us a pencil sketch of the form which he considered that *Proricaris* would show if the fragments were pieced together—namely, a subquadrate cephalothorax (as seen sideways), indented in front, and boldly curved behind, and eight abdominal segments, tapering rather rapidly to the last, which might have been furnished, he thought, with caudal spines. We find, however, that most probably the part taken for the cephalothorax is a detached joint of one of the swimming feet of *Eurypterus* or *Pterygotus*,[3] and that other parts of such limbs, as well as portions of the body-segments of the same kind of animals, supplied the material for the supposititious body of *Proricaris*.

ADDENDA.

I. Kolmodin's *Leperditia megalops*, 'Bidrag till Kännedomen om Sverges Siluriska Ostracoder,' 1869 (8vo. Upsala), p. 15, pl. –, fig. 7, is also a *Callizoe*, like that figured by Angelin.

IV. The *Echinocaris* from Devonshire has been described and figured in a paper on some Devonian Entomostraca, by Prof. T. R. Jones and Dr. H. Woodward, in the 'Geological Magazine' for September 1889, as *E. Whidbornei*, page 385, pl. 11, fig. 1.

XII. Robert Etheridge, Esq., junior, has figured and described in the 'Memoirs of the Geological Survey of New South Wales; Palæontology, No. I: The Invertebrate Fauna of the Hawkesbury-Wianamatta Series of N S.W.' 1888 (fol. Sydney), *Estheria Coglani*, p. 6, pl. 1, figs. 1–5, and *Estheria* (?), sp. *loc. cit.* figs. 6–10.

[1] Referred to in Dr. Bigsby's *Thesaurus Devonico-Carboniferus*, 1878, p. 27, as '*Proricaris McHenrici*, W. H. Baily, Passage-bed, U[pper Devonian], Kiltorkan, co. Kilkenny, Ireland; *Geol. Mag.* ix. p. 91;' also at p. 253, as '*Proracaris McHenrici*, Baily ? LLS. [Lower Limestone Shale, including . . . . Yellow Sandstone (Ireland) ?] Kiltorkan.'

[2] *Report Brit. Assoc.* 1884, p. 217.

[3] We may notice that both of these genera are recorded as occurring in the sandstone of Kiltorkan; *Geol. Mag.* vol. ix. p. 91, 1872.

Report of the Committee, consisting of Professor W. C. WILLIAMSON (*Chairman*) *and* Mr. W. CASH (*Secretary*), *appointed to investigate the Flora of the Carboniferous Rocks of Lancashire and West Yorkshire.* (*Drawn up by* Professor W. C. WILLIAMSON.)

On the present state of the Inquiry into the Microscopic Features of the Coal of the World, and into the Organisation of the Fossil Plants of the Coal-Measures.

IN the year 1881 I determined to undertake the microscopic examination of as many of the coals of the entire world as I could obtain. My chief object was to learn how far such examinations would throw light upon the origin and formation of these coals, and especially on the two dominant features of the nature of the mineral charcoal contained in many of them, and of the extent to which these coals contained the spores of cryptogamic forms of vegetation. My applications, issued in various directions, for specimens upon which to work, soon met with a noble response. The time which could be devoted to the inquiry has been limited through the prior claims of my inquiries into the organisation of the fossil plants of the coal-measures. Nevertheless considerable progress has been made. At the York meeting of the British Association in 1881 I made a few preliminary observations on the results obtained up to that date from the study of the coals of Eastern Scotland and of South Wales. But since then much more work has been done, the coals from the following coal-producing regions having been already investigated :—

Eastern Scotland	Australia
South Wales	Sweden
Forest of Dean	Arctic regions
Whitehaven	Nova Scotia
Durham	Borneo
South Africa	Flintshire
Japan	North Staffordshire
New Zealand	Belgium, *in part*
India	

Sections—271 in number—have been prepared of all the above coals, with the exception of the two last, and the mineral charcoals of all these, including the North Stafford and Belgian examples, have been studied. Three thousand four hundred and fifty-nine (3,459) fragments of mineral charcoal have been examined, and microscopic preparations of 211 of the most characteristic of these are also stored in my cabinets.

I have a definite object in making this personal communication. As you must have already inferred, I have been under immense obligations to many friends in various parts of the globe for the collection of the materials upon which I have been working, and the cellars of my house contain numerous still unopened cases from additional localities. Hearing nothing in the way of results from their kind exertions, I am afraid that some of those who have thus aided me may deem their labour thrown away, and I am anxious to let them know that this is very far from being the case.

The further question arises, What are the future prospects of this inquiry?

I am still carrying on my investigations, but the cause of interruptions already referred to is not yet exhausted. Still more important is the fact that at my advanced age I can scarcely expect to live to complete my task. But I am taking every precaution that the work already done shall not be thrown away. Specimens of every coal examined are being preserved in the museum of Owens College. When the time comes that I must lay down my pen and pencil, all my records of observations, and of illustrative microscopic preparations made, will be found in the museum of the same college. Hence it will be open to some of the younger generation of histologists, who may care to do so, to utilise my materials, and to carry the work to a final issue.

In the department of carboniferous vegetation much progress has also been made. The fact that the stems of Calamites, Lepidodendra, and many other cryptogamic plants grew exogenously, first announced at Edinburgh in 1871, and which was then and long afterwards rejected almost universally, is now as universally accepted by geologists and botanists. The only exceptional plants have until lately been the ferns. Hitherto no proof has been available that their stems ever grew exogenously. I am now, however, in a position to prove that the fine exogenous arborescent stem to which I long ago gave the name of *Lyginodendron Oldhamium* is part of the same plant as the fern petioles and leaves to which I gave the name of *Rachiopteris aspera*; so that the ferns must now be added to the remarkable group of Carboniferous cryptogams of which the stems and branches grow exogenously. But another botanical heresy now comes to the front. In all the Carboniferous Lycopods the vascular bundle was primarily solid and contained no medulla. As the twig enlarged into a branch, this bundle expanded into a gradually enlarging vascular ring, enclosing a medulla which enlarged *pari passu* with the ring. Many botanists now decline to believe this. But, as in the case of the exogenous theory, the fact will fight its way into acceptance, though contrary to most known analogies amongst living plants.

Report of the Committee, consisting of Mr. JAMES W. DAVIS, Mr. W. CASH, Dr. H. HICKS, Mr. CLEMENT REID, Dr. H. WOODWARD, Mr. T. BOYNTON, *and* Mr. G. W. LAMPLUGH (*Secretary*), *appointed for the purpose of investigating an Ancient Sea-beach near Bridlington Quay.*

No further excavation of the buried cliff beds has been undertaken by your Committee during the past year; but further investigations, should they be considered desirable, will have been greatly facilitated by the removal of the talus-heaps of previous workings by the action of the sea.

The tedious task of gelatinising and repairing the bones obtained last year has been proceeded with, and a part of them are now in a condition for determination. When further progress has been made, it is proposed to place the whole collection in the hands of competent osteologists for critical examination, the results of which we hope to embody in our next report.

The excavated section was visited last autumn by a party which

included several foreign geologists, after the meeting of the Geological Congress in London.

Your Committee ask to be reappointed, without grant, for the immediate purpose of arranging for the determination and disposal of the specimens.

Fifteenth Report of the Committee, consisting of Drs. E. Hull *and* H. W. Crosskey, Sir Douglas Galton, Professor G. A. Lebour, *and* Messrs. James Glaisher, E. B. Marten, G. H. Morton, W. Pengelly, James Plant, J. Prestwich, I. Roberts, T. S. Stooke, G. J. Symons, W. Topley, Tylden-Wright, E. Wethered, W. Whitaker, *and* C. E. De Rance (*Secretary*), *appointed for the purpose of investigating the Circulation of Underground Waters in the Permeable Formations of England and Wales, and the Quantity and Character of the Water supplied to various Towns and Districts from these Formations.* (*Drawn up by* C. E. De Rance, *Reporter.*)

Since your Committee were appointed at Belfast, fourteen years ago, the recognition of the great value of our underground water stores has made wide progress, as affording efficient supplies of water to corporations, local boards, and public companies, free from organic impurity, regular in quantity during periods of drought, yielded at a constant temperature throughout the year, and obtained, as a rule, at a smaller cost than gravitation supplies, and almost invariably at a less cost as regards legal or Parliamentary expenses. The publication of the results already obtained by your Committee has been greatly appreciated by engineers and contractors, and has undoubtedly helped and supported recommendations of water supplies from underground sources. As time goes on, a large number of borings are annually made, and there being no other recording agency of the results obtained than those collected by your Committee, they ask for reappointment; but they note with satisfaction that numerous provincial societies, represented by delegates to the Association, are giving attention to this subject, and publishing results, as the Liverpool Geological Society, the Hampshire Field Club, and the Hertfordshire Natural History Society.

Looking to the comparatively small circulation of the Transactions of these societies, your reporter has thought it well to include the more important results so obtained in the present Report, as they were obviously the outcome of the suggestions made by Section C as to inquiries that might be taken up with advantage by provincial societies.

Your Committee, in the present Report, almost entirely follow the lines of their first instruction, to inquire into the waters yielded by the Permian and Trias, following those formations from Teignmouth in Devonshire to the mouth of the Tyne in Northumberland.

Your Committee think it advisable to combine the results obtained during the past two years, as to the effect of rainfall on the varying height of wells, and to publish them in a graphic form in their Report next year, should they be reappointed.

Your Committee this year have to ask for a grant of 5*l.*, should you approve their reappointment.

Appendix I.—*Permian and Triassic Wells.*

Devonshire.

Information collected from Mr. G. W. Ormerod, F.G.S. *Well and* 12-*inch boring at the Teignmouth Local Board Waterworks, Coombe Vale, N.W. of Teignmouth, sunk by* Mr. Vivian, C.E., 1887.

Feet.		Feet.
	Details not given	18
	Soft rock (iron cylinders)	20
82	Conglomerate (*bottom of old well*)	44
	Sandy rock, with angular and sub-angular fragments	41
	Sandy rock, with pebbles	$0\frac{3}{4}$
	Soft rock, with few pebbles	$28\frac{1}{4}$
	Hard rock	3
	Soft conglomerate	17
	Soft rock, with fragments	2
	Fine red rock (*first water in B.H.*)	8
	Fine sandstone, with pebbles	11
	Sand, with large pebbles	3
	Conglomerate soft	7
	Fine rock, with pebbles	2
	Conglomerate, small pebbles	3
	Compact conglomerate, hard pebbles	1
	Sandstone, with pebbles	11
	Large pebbles	2
	Sandstone, with pebbles	3
	Compact sand, with few pebbles	5
	Soft sand, with pebbles	5
	Sand, with few large pebbles (*water*)	5
	Rather loose sand, with clay	68
	Harder rock (*water*)	4
332	Soft crumbling rock (no fragments)	20

Mr. Ormerod states that the volume of water was not much increased by the boring. For details refer to the 'Trans. Devon. Assoc. of Science, Lit., and Art, 1888,' pp. 391–97.

Worcestershire.

Information collected by C. E. De Rance *from* Mr. Walter T. Layton, C.E.

1. Burcot Pumping Station of the East Worcestershire Waterworks Company. **1***a*. Well and bore-hole constructed in 1881. **2**. **3**. Well, 100 feet; bore-hole, 200—total, 300 feet. **3***a*. None. **4**. When pumping is suspended for six hours, the water rises and overflows the surface. **5**. Could obtain $2\frac{1}{4}$ million gallons. Yield at present, pumped down to 70 feet from the surface, 516,000 gallons per day. **6**. Does not vary. **7**. No.

8. *Analysis by* William A. Tilden, D.Sc., F.R.S. *Sample taken, April* 1881.

		Parts per 100,000.	
Total dissolved solids		12·250	
Nitrogen in the form of nitrates		·390	
„ „ „ nitrites		——	
Free ammonia		·003	
Chlorine		1·300	
Hardness, temporary	2·320	5·570	Water turbid.
„ permanent	3·250		

Analysis by C. MEYMOTT TIDY, M.B. *Sample taken March* 29, 1887.

			Grains per gallon.	
Total solid matter			9·60	
Nitrogen as nitrates and nitrites			0·426	
Organic carbon	0 068	Parts per 100,000.	——	
„ nitrogen	0·024			
Lime			3·47	
Magnesia			0·504	
Sulphuric anhydride			0·88	
Chlorine			1·08	
Hardness, temporary	6·2		10·0	Water clear.
„ permanent	3·8			

Analysis by Dr. E. FRANKLAND, F.R.S. *Sample taken April* 28, 1887.

Total solid residue		11·72	
Nitrogen as nitrates and nitrites		·407	
Organic carbon		·020	
„ nitrogen		·012	
Magnesia		·71	
Chlorine		1·2	
Hardness, temporary	1·1	5·0	Water clear.
„ permanent	3·9		

9. No section preserved. It commences in the upper bunter and probably terminates in the pebble beds, or middle bunter. **9***a*. All pervious. **10**, **11**. None. **12–14**. No.

Information collected from Mr. S. G. PURCHAS, M.Inst.C.E., *Worcester.*

1. Trial boring at Charford, near Bromsgrove, 100 yards of the road from Bromsgrove Station to Stoke Heath, and about 30 yards N.E. of the Spadesbourne Brook, which lower down the valley becomes the Salwerpe. **1***a*. March, 1882. **2**. About 238 feet above mean sea level. **3**. Boring, 300 feet; diameter, $2\frac{1}{4}$ inches. **4**. Overflowed and still does so; never pumped. **5**. Quantity gauged flowing away in January, 1885, was 100 gallons per minute; in July, 1887, it was reduced to 86·6 gallons per minute; in October of this year to 36 gallons per minute, which was the quantity gauged by C. E. De Rance on April 25, 1888. **7**. The top of the bore-hole is about 4 feet above the stream. **8**. Analyses of the water were made by the following:—

By Mr. J. ALFORD WANKLYN. *Sample taken March* 7, 1887.

Hardness, about 20 degrees.

	Parts per million.
Free ammonia	0·02
Albuminoid ammonia	0·01

	Grains per gallon.
Carbonate of lime	7·4
„ magnesia	5·1
Sulphate of magnesia	0·7
Chloride of magnesium	1·2
	14·4

Mr. Wanklyn comments on the unusual quantity of magnesia.

Sample taken same time, analysed by Mr. G. H. OGSTON.

		Grains per gallon.
Chlorine		0·91
Sulphuric acid		1·71
Nitric acid		·72
Lime		3·80
Magnesia		3·02
Hardness, temporary	0·7	7·7
„ permanent	7·	

Excellent water for drinking and manufacturing purposes. Total solid matter per gallon, 16·60 grains.

Sample taken March 29, 1887, *analysed by* Dr. C. Meymott Tidy, M.B.

		Grains per gallon.
Total solid matter		18·88
Chlorine		1·368
Sulphuric acid		1·18
Nitric acid		none
Lime		4·81
Magnesia		3·243
Organic carbon		0 021 } parts per
„ nitrogen		0·008 } 100,000.
Hardness, temporary	8·1 }	15·3
„ permanent	7·2 }	

Analysis made by Dr. E. Frankland, F.R.S., *of sample taken April* 28.

		Parts per 100,000.
Total solid residue		23·80
Chlorine		1·3
Magnesia		4·41
Organic carbon		0·012
„ nitrogen		0·005
Hardness, temporary	13·6 }	18·9
„ permanent	5·3 }	

Hardness in grains per gallon.

Temporary	9·52 }	13·23
Permanent	3·71 }	

9. The boring appears to be wholly in the Keuper sandstone, which is here traversed by three calcareous beds of 'rag,' which are probably impermeable. Magnesia occurs in marly partings in the adjacent district.

Information collected from Mr. Purchas, M.Inst.C.E., *City Engineer of Worcester, by* C. E. De Rance.

Analysis of Malvern Water. *By* Dr. Sheridan Muspratt, M.D.

		Grains per gallon.
Carbonate of	lime	0·43
„	„ magnesia	0·41
„	„ iron	0·03
„	„ soda	0·28
Sulphate	„ lime	0·15
„	„ soda	0·43
Chloride	„ sodium	0·87
„	„ magnesia	0·14
Iodide	„ potassium	Traces
Silicic acid		0·20

Leicestershire.

Collected by Mr. James Plant.

Borings to the Upper Keuper Sandstone at Leicester.

1. Messrs. Fielding, Johnson & Co., Spinners, Bond Street, Leicester. **1***a*. Uncertain. No. **2.** 214 feet. **3.** Well—depth, 50 feet; diameter, 7 feet. Bore—depth, 80 feet; diameter, 7 inches. Total depth, 131 feet. **3***a*. None. **4.** 20 feet from top. **5.** Increase of quantity of 200 per cent. entirely from the boring. **7.** Yes.

8. Very hard from carbonate and sulphate of lime. This water is not pumped into the boiler, but only used for condensing the steam, and the hardness is of no consequence. It is quite free from impurity.

		Feet.
9. Drift beds	Soil	1
	Upper boulder clay	5
	Lower boulder clay	9
Upper Keuper marl	Upper Keuper marls; N.B.—Two gypsum beds yielding water	35
Upper Keuper sandstone	Keuper shales with gypsum, A	16
	Middle sandstone, B	14
	Lower shales, C	11
Red marl, with four gypsum beds, and thin beds of white sandstone, all yielding water		40
	Total	151

9a. All the sandstone beds and the gypsum. **10.** There may be. **11.** Yes. **12, 13.** None. **14.** No. **15.** None are known. **16.** For every gallon from the well before boring, they have now three gallons after boring.

Messrs. Davis & Co., Manufacturers, Leicester.

1. London Road. **1a.** Uncertain. **2.** 220 feet. **3.** Well, 70 feet deep, 6 feet diameter. Bore, 80 feet deep, 6 inches diameter. **3a.** None. **4.** 20 feet. **5.** Increase 150 per cent. since boring. **6.** Not known. **7.** Yes. **8.** Hard from carbonate and sulphate of lime, but used only for condensing purposes.

		Feet.
9. Drift	Drift beds	20
Upper Keuper marl	Upper Keuper marl, with gypsum beds	25
Upper Keuper sandstone	Upper Keuper sandstone and shales	45
Red marl	Red marl, with gypsum beds, and thin beds of sandstone	60
	Total	150

10. There may be. **11.** Yes. **12–14.** None. **15.** None known. **16.** Increase of water more than 150 per cent. entirely through the boring.

Messrs. Raven & Co., Manufacturers, Leicester.

1. Wharf Street, Leicester. **1a.** October 1887. **2.** 186 feet. **3.** Bore, 120 feet deep, 7 inches diameter. Bore, 84 feet deep, 6 inches diameter. Total depth, 204 feet. **4.** 20 feet from the surface. **6.** Yes. **8.** Very hard from carbonate and sulphate of lime. This water is not pumped into the boiler, but only used for condensing the steam, and the hardness is of no consequence. It is quite free from impurity.

		Feet.
9. Boulder clay	Drift and soil	8
Upper Keuper marl	Upper Keuper marls	25
	Upper shaly sandstone, A	30
Upper Keuper sandstone	Middle sandstone, B	20
	Lower shaly sandstone, C	22
Red marl	Gypsum bands and red marl	69
	Red marl, with bands of shaly sandstone	30
	Total	204

10. Probably. **11.** Yes. **12–15.** None known. **16.** An abundant supply of water is found.

Lincolnshire.

Collected by C. E. DE RANCE *from* Mr. JAMES PILBROW, M.Inst.C.E.

1. Bourn, Lincolnshire, Waterworks, in higher part of the town. **1a.** 1856. No. **2.** **3.** Bore-hole, 4 inches diameter; 94 feet in depth. The last 2 feet being

a natural cavity containing a strong natural spring. **4**. On entering the cavity, the water rose to the surface with great rapidity, and rose 39 feet 9 inches above. **5**. The yield was 575,201 gallons; it has been pumped. **6, 7**. No. **8**. By Professor Brand's test gave 19·4 degrees of hardness, chiefly bicarbonate of lime.

		Feet.
9.	Gravel	?
	Hard shelly limestone	32
	Various beds	?
	Compact hard rock	6
	Cavity with water	2
	Hard rock	(+)
		94

10. The surface springs in the top gravel were cut off by a cast-iron pipe driven tightly into the hard shelly limestone.

The water supplies Bourn and the town of Spalding, 10 miles distant.

Lancashire.

Through the courtesy of Mr. Mather, M.P., the details of the Liverpool Corporation boring for water at Liverpool have already been given.

In abstract they were as follows:—

Feet.		Feet.
1,300	Red sandstone with few pebbles	1,026
	Compact hard red sandstone, with millet-seed grains, but cemented together	274

The following analysis, by Dr. Campbell Brown, D.Sc., of the beds passed through are of interest in their bearing on beds since discovered in borings to the east:—

Specimen A.—Hard sandstone composed of angular grains, taken from the pebble beds at 700 feet.

Specimen B.—Red sandstone, rounded grain, taken from lower mottled at 1,180 feet.

Specimen C.—Slightly marly sandstone, composed of granular or powdery particles, taken at a depth of 1,280 feet.

Result of analysis in parts per cent.:—

	A.	B.	C.
Sand and insoluble matter	95·16	94·20	86·72
Alumina and oxide of iron	0·86	1·94	2·66
Lime	1·15	1·03	4·74
Magnesia	0·88	0·36	0·82
Carbonic acid in combination with lime and magnesia	1·43	1·00	4·30
Traces of other substances	0·52	1·47	0·76
	100·00	100·00	100·00

The hardness of the water at 600 feet was less than at the surface or at the bottom. The proportion of common salt increased from 600 to 1,300 feet.

Information collected by C. E. De Rance *from* A. Timmins, A.M.I.C.E.

Boring for water at Halewood, near Hunt's Cross, made for the Cheshire Lines Railway in 1882.

		Feet.
	Stiff clay	45
	Quicksand	10
	Stiff sandy clay	38
	Sandy clay	2
	Stiff clay	20
	Loamy sand	4
	Clay with small stones	10
	Sandy gravel	8
138·0	Vein of sand or rock	1
414·0	Red marl	276

The age of these marls at the base of this section is doubtful; they were examined microscopically by the late Mr. John A. Phillips, F.R.S., who found a clay containing fragments of angular quartz with a substance resulting from the decomposition of felspars. Chemical analysis of the marls made by Mr. A. Timmins showed:—

	At 303 feet.	At 373 feet.
Oxide of iron and alumina	3·21	7·68
Calcium carbonate	18·66	16·68
Magnesium	·00	·07
Insoluble matter	77·67	75·40
	99·54	99·47

Mr. Timmins finds the average amount of oxide of iron and alumina, in the marls of Permian age, to be 3·6 per cent., and in those of Keuper age to be 13·4.

Eccleston Summit.

Feet.		Feet.
	Loamy soil and stones	20
33	Red loamy soil	13
	Fine red sandstone, pebble	10
	Marl, salmon-coloured	2
	Sandstone	4
	Marl red	5
	Fine red sandstone	7½
	Red loam	9½
	Light red sandstone	3
	Red marl	6
	Fine light red sandstone	13
	Red loam	23
	Fine red sandstone	54
	Grey marl	5
	Sandstone, coarse grey, pebble	6
	Sandstone, fine red	5½
	Red and grey marl	3½
	Fine light red sandstone	41
247	Loamy sandstone	16

The whole of the above section is on the Pebble Beds; it is interesting as showing the frequent occurrence of beds of marl.

Boring at Gateacre Bridge, Childwall Valley, made for the Liverpool Corporation, 1887, by Messrs. Timmins & Sons, Runcorn, about 500 yards from the Bellevale and 1,100 yards from the Netherby borings already reported, nearly in a line between the two.

East of Prescot.

Boring at Portico Lane Bridge, on the Huyton and St. Helens Branch Railway (L.N.W.R.):—

Feet.		Feet.
	Red sandstone, millet-seed grain	54
95	Red sandy marl	41
114	Fine red sandstone	19
125	Red marl	11
160	Light red sandstone	35
162	Red marl	2
195	Light red sandstone	33
215	Fine dark ,,	20
581	Coarse red sandstone, millet-seed	366

Mr. Timmins gives the following interesting analyses:—

L.N.W.R. Co., Portico Lane. Sample from 54 ft.

	Per cent.
Iron oxide and alumina	3·46
Calcium carbonate	9·90
Magnesia	0·91
Insoluble matter	83·59

Liverpool Corporation, Bootle. Sample from 1,290 ft.

	Per cent.
Iron oxide	1·03
Alumina	7·71
Calcium carbonate	10·63
Magnesia	1·44
Insoluble matter	76·69

The samples chemically and lithologically resembling each other, they are referred by some to the Lower Mottled sandstone, by others to the Permian.

Half a mile south of the railway boring is that at Holt Lane Quarry, carried out at the bottom of the quarry, which is excavated in undoubted Pebble Beds dipping west at 25°.

The section met with is as follows. The boring is not completed.

	Feet.
Sandstone with pebbles	130
'Millet-seed' grained sandstone	35 (+)

L.N.W.R. boring at the Eccleston Summit, at the entrance of the Thatto Heath deep cutting in the Bunter Pebble Beds.

Gateacre Section.

Feet.		Feet.
	Clay and gravel	8
	Light red sandstone	170
	Grey sandstone	15
	Light red sandstone	4
	Grey sandstone	22
273	Hard red massive sandstone	54
	Grey marl	1½
	Fine red sandstone	19½
	Coarse brown sandstone	10
342	Hard red massive sandstone	38
	Fine grey sandstone	3½
	Dark red ,,	23½
	Very fine red sandstone	57
433	Grey sandstone with pebbles	·6
	Dark red marl	1⅓
435	,, sandstone	0½
440½	Dark purple and grey saponaceous marl	5½

The whole of the first 435 feet belongs to the pebble beds; the underlying sandstone first recognised at the Bootle boring of the Liverpool Corporation Waterworks by your reporter appears to be absent, and the middle bunter rests directly on 5½ feet of coal-measure shales.

The new borings at Knowsley and Kirby made for the St. Helens Corporation Waterworks are now completed. The following sections are furnished by the Corporation Engineer, Mr. D. M. F. Gaskin, M.Inst.C.E.:—

Kirby Boring.

Feet.		Feet.
	Turf	1½
	Clay	4
8	Red sand	2½
	„ sandstone	2½
	Yellow „	2
	Red „	4
	„ „ coarse	3
	Mottled „ pebbles	3
	„ „ with yellow veins	5½
	Grey „ pebbles	6½
115	Red „ „	78½
	„ „ with white	3
	„ „ pebbles	26
	Variegated sandstone	3
	Red sandstone and pebbles	28
	Coarse-grained sandstone	9
	Red sandstone	70
	Variegated sandstone	0½
	Red „	7
	Variegated „	0½
	Red „ pebbles	38
	White „ „	0½
352¼	Red „ „	52
	„ marl	0¼
	„ sandstone, with bands of white stone	40
460	Soft red sandstone	67½

The lower 107¾ feet are referable to the beds occurring between the base of the Pebble Beds and the Coal-measures at Winwick, Parkside, and Collins Green, and, like them, full of sulphuret of iron.

Knowsley Waterworks Boring.

Feet.		Feet.
	Surface soil and sand	3
	Brown marl	3
9	Red and yellow marl	3
	Red sandstone	6
	Soft „	42
	Red „ veins of yellow	72
	Close-grained sandstone, veins of yellow	33
	„ „ without veins	28
198	Gritty grey sandstone	9
	Red marl	1
	Red sandstone	27
	Red, with veins of calcite	6
	Red sandstone	25
	„ „ close-grained	1
	Red marl	3½
	White sandstone	6½
	Grey „	3

Feet.		Feet.
	Red and white sandstone	22
	Red marl	$1\frac{1}{2}$
	Coarse red sandstone	$20\frac{1}{2}$
	Red marly "	20
	Red marl	28
	Soft grey sandstone	47
	Hard white "	16
478	Fine soft red sandstone	52
479	Red sand	1
640	Soft red sandstone	161
	Mottled "	3
687	Soft red "	44

The lower soft beds were found very water-bearing; the dip was to the north, at $6\frac{1}{2}°$.

Yorkshire and Durham.

Professor Lebour states: for water-supply purposes it does not appear necessary to notice any of the subdivisions generally recognised in the Durham Magnesian Limestone above the marl slate. The following classification gives the important divisions for water-supply purposes:—

1. Magnesian limestone: concretionary, brecciated, compact and cellular; varies from an eminently hard and crystalline condition to an earthy one, and from containing many fossils to none at all.

2. 'Marl slate,' a compact, flaggy, dark grey, calcareous or sandy shale, often forming a 'fish bed,' generally impervious, and a yard in thickness.

3. Magnesian limestone, resembling that below, generally 6 feet to 10 feet thick, sometimes absent.

4. Yellow sands: generally a loose, incoherent, coarse sand, with more or less calcareous cement, often concretionary, sometimes solid; very irregular in thickness, from 60 feet downwards, and sometimes absent; contains a large amount of water.

Unconformity.—Red Sandstone with Coal Plants (Upper Coal-measures).

Professor Lebour has mapped the Durham coal-pits, and indicated the outcrop of the Permian series, as well as the position of all sinkings and borings that have been put down to the coal-measures, through the Permian.

The numerous sections obtained in boring for rock salt, from Middlesborough to the district south of Hartlepool, have clearly defined the area where potable water may not be looked for. The boring put down in 1859, for Messrs. Bolckow & Vaughan, was made to procure a water supply for their well-known ironworks. Large supplies of water were obtained from the upper pervious strata; but it contained so large a quantity of sulphate of lime as to be useless for the purpose required, and the boring was discontinued at a depth of 1,313 feet, the details of which are given in the Sixth Report of your Committee.[1]

Since the publication of these details, papers have appeared by Mr. E. Wilson, F.G.S., and Mr. W. J. Bird. The latter author gives a classification of the measures passed through, which is valuable in correlating

[1] In the Sixth Report, 1881. The beds bored through are described by your Reporter as belonging to 'the Keuper waterstone, lower mottled sandstone, and Permian.' In the Seventh Report this classification is again alluded to.

the various beds passed through, in the sections published and unpublished, occurring in this area. The sequence is as follows, in descending order:—

	Max. thickness.
Upper gypseous marls	450 feet
Red sandstones and marls	1,117 „
Lower gypseous marls	279 „
Saliferous beds, anhydrite and salt	267 „
Magnesian limestone	—
Red and grey sandstone	—
Coal-measures	—

Mr. Bird points out that a bed of anhydrite invariably forms the top of the saliferous beds. It is worthy of note that the Zechstein of Saxony contains rock salt alternating with anhydrite. Immediately over the anhydrite is a bed known as the 'rotten marl,' which occasionally leads to the collapse of the borings.

A boring made at Oughton in 1827, published in the Sixth Report, is stated to be unreliable, the coal noted as occurring being probably an error.

A boring at Greatham, a mile to the south of Oughton, has proved the following section, communicated by Mr. Bird, bored at Marsh House, Greatham, for the Greatham Salt Boring Company, Lim.:—

	Ft.	in.		Ft.	in.		
	71	11	Drift	71	11		
Red Sandstone and marls. 587′ 6″			Red sandstone	300	7	Red sandstone with subordinate beds of marl. 507′ 1″	
			Red sandstone with beds of marl	77	6		
			Red sandstone	15	2		
	579	3	Red sandstone with beds of marl	114	7		
			Red sandy marl	8	6	Red marls with gypsum and salt. 309′ 9″	Saliferous beds.
			Red marl with blue joints	8	6		
			Red sandy marl	21	3		
			Red marl	20	3		
	659	5	Red marl with blue joints	21	8		
Lower gypseous marls. 203′ 7″			Red marl with veins of gypsum	18	8		
			Red marl, veins of gypsum, and blue joints	106	11		
			Red marl, veins of gypsum, and blue spots	68	2		
	863	0	Red marl with veins of gypsum	0	10		
Saliferous beds. 109′ 9″			Anhydrite	11	0		
			Red marl (rotten)	15	0		
			Rock salt	57	2	Rock salt. 83′ 9″	
			Salt and anhydrite mixed	14	3		
			Rock salt	11	4		
			Anhydrite	1	0		

The left-hand column gives the classification adopted by Mr. Bird ('Trans. Man. Geol. Soc.' vol. xix. part xx. p. 572), the column on the right that of Mr. Wilson, F.G.S. ('Quart. Jour. Geol. Soc.' Nov. 1888).

Boring at Seaton Carew, 1887–89, *from* Mr. W. J. Bird.

Ft.	in.		Ft.	in.	
		Brown clay	6	0	Drift.
		Red clay	6	0	
		Red pinnul and cobbles	9	0	
		Soft red sandy marl	12	0	
33	0	Red sandy marl	3	0	

Ft.	in.		Ft.	in.	
		Red and grey sandstone	7	0	Red sandstones and marls.
		Red marl	2	0	
		Grey sandstone	5	0	
		Red marl, beds of sandstone	10	0	
		Red sandstone	20	0	
		Grey sandstone	2	0	
		Red sandstone	13	0	
		Grey sandstone	1	0	
		Red sandy marl	47	0	
		Red and grey sandstone	10	0	
		Red marl	15	0	
		Red marl, beds of grey and red stone	8	0	
		Red marl with blue joints	35	0	
		Red marl with beds of grey stone	24	0	
		Red marl with beds of grey marl	33	0	
289	0	Red marl with blue joints	24	0	
		Red marl with blue joints and veins of gypsum	171	0	
		Red marl and veins of gypsum	7	5	
		Anhydrite	13	0	
483	5	Blue marl and veins of gypsum	3	0	
		Anhydrite	1	0	
		Red marl with veins of gypsum	10	0	
		Dark marl and gypsum mixed	2	7	
522	0	Anhydrite with black joints	25	0	
		Magnesian limestone, spots of gypsum	27	0	
		Light grey magnesian limestone, spots and veins of gypsum	38	0	
		Dark grey limestone, with spots and veins of gypsum	16	0	
		Dark blue shale (slight feeder of rock oil)	3	0	
		Anhydrite, with beds of dark blue shale and gypsum	35	0	
		Light grey limestone and gypsum	7	0	
		Blue shale	2	0	
		Light grey limestone	11	0	
		White limestone	90	0	
		Hard white limestone and gypsum	12	0	
		Dark grey limestone and anhydrite	20	0	
		Light grey limestone and gypsum	18	0	
		Light grey limestone	29	0	
		Limestone and gypsum mixed	31	0	
		Grey limestone and gypsum	11	0	
		Light grey limestone and gypsum	33	0	
		Light grey limestone	50	0	
		Light grey limestone, spots of gypsum	45	0	
		White limestone	107	0	
		Light grey limestone	23	0	
		Broken light grey limestone (brim feeder)	23	0	
		Light grey limestone	9	0	
		Light grey limestone with spar cavities	9	0	
		Light grey limestone	7	0	
		White limestone	82	0	
		Light grey limestone with a little gypsum	23	0	
		Dark grey limestone with gypsum	17	6	
		Dark limestone, spots of gypsum	59	6	
1,400	0	Dark grey limestone	40	0	
		Dark grey shaly sandstone	10	0	
1,427	6	Red and grey shaly sandstone	17	6	
		Black shale	0	6	
		Dark grey shale	1	0	
		Dark grey sandstone	1	0	
		Grey sandstone and black joints	40	6	
		Very coarse grey sandstone	15	0	

Ft. in.		Ft.	in.
	Dark grey sandstone	0	6
	Black shale	0	6
	Red and grey sandstone	1	7
	Black shale	12	4
	Shaly sandstone	2	6
	Black shale	10	0
	Grey sandstone	4	0
	Dark grey sandy shale	0	7
	Coal	0	10
	Dark brown fireclay	1	2
	Black sandy shale	2	8
	Dark grey sandy shale	1	8
	White sandstone	26	8
	Dark grey sandstone	5	0
	Light grey sandstone	12	8
	Dark shaly sandstone, coal partings	1	4
	Black shale	9	6
	Coal	1	2
	Dark black shale and prickly	0	4
	White and grey sandstone	6	0
	Black shale	8	0
1,600 0	Fine grey sandstone	6	0
	Dark grey sandstone	3	6
	Black shale	7	0
	Black shale with beds of dark grey sandstone	6	6
	Black shale	6	0
	Black shale with beds of grey sandstone	7	11
	Coal and shale	0	1
	Dark brown fireclay	2	0
	Dark grey sandstone	6	0
	Dark shaly sandstone	3	0
	Yellow sandstone	8	9
	Coarse light grey sandstone	16	6
	Hard yellowish sandstone	2	3
	Coarse light grey sandstone	3	6
	Coarse grey sandstone	1	6
	Dark grey shaly sandstone	1	6
	Black shale	8	0
	Dark grey sandy shale	3	0
	Dark blue shale	7	0
	Black shale	4	0
	Dark brown shale	3	0
	Grey shaly sandstone	10	0
	Coarse grey sandstone (*coal* scars)	24	0
	Dark grey shaly sandstone	5	0
	Yellowish shaly sandstone	6	0
	Dark shaly sandstone	8	0
	Black shale	24	0
	Grey sandstone with black shale	10	0
	Coarse grey sandstone, black joints	10	0
1,814 0	Grey sandstone	14	6

The boring was commenced with a diameter of 6 inches; at 1,340 feet it was contracted to $4\frac{1}{2}$ inches. The 10 feet of red marl and gypsum is the 'rotten marl' overlying the salt-measures of the district. The first magnesian limestone met with contained 42·35 per cent. of carbonate of magnesia, and it is proposed to utilise it. At 1,150 feet occurred a brecciated limestone, with a strong feeder of saturated brine, the flow of which appears to be well maintained.

The following is the abstract of the above section:—

Ft.	in.		Ft.	in.
33	0	Drift	33	0
289	0	Red sandstone and marls	256	0
483	5	Lower gypsum marls	194	5
522	0	Anhydrite beds	38	7
1,400	0	Magnesian limestone	878	0
1,814	6	Coal-measures	414	6

About half-a-mile north-west of the Seaton Carew, Messrs. Casebourne and Co., Limited, put down the following boring in 1887 for water for their Cement Works at West Hartlepool :—

Ft.	in.		Ft.	in.
30	0	Well, details unknown	30	0
		Red sandstone	9	0
		Red sandy marl	10	0
		Red sandstone with beds of red marl	31	0
		Red sandstone and marl	57	0
		Red marl, beds of red sandstone	27	0
		Red and grey sandstone, beds of red marl	26	0
		Red sandstone	25	0
		Red marl	35	0
		Red marl with beds of sandstone	20	0
		Red marl	38	0
		Red marl, thin beds of sandstone	32	0
385	0	Red marl	45	0
		Red marl with veins of gypsum	95	0
		Red marl, veins of gypsum and blue joints	55	0
		Red marl with blue joints	4	2
		Red marl with blue spots, veins of gypsum	4	6
		Red marl with blue joints	24	10
		Red marl with red sandstone	10	0
		Strong marl, thick veins of gypsum	21	6
605	6	Red marl, veins of gypsum, and blue joints	5	6
		Anhydrite	4	0
		Anhydrite with veins of gypsum	12	0
		Anhydrite	2	6
		Blue marl	0	8
		Red marl, blue joints, and veins of gypsum	27	10
		Anhydrite	7	0
		Anhydrite with black joints and gypsum	11	0
		Anhydrite with black joints	16	0
		Anhydrite with spots of gypsum	18	6
714	4	Anhydrite with gypsum	9	4
		Anhydrite mixed with limestone	15	8
770	0	Limestone with gypsum	40	0

Appendix II.—*Hertfordshire Chalk Wells.*

Table of Observations of Water-level at Barley, Herts, made by the late Mr. John Pearce, 1864–86, *showing the number of feet in the well, in the middle of the village, on the north side of Mr. Pearce's house, on the* 1*st of each month. Level of curb* 305 *feet (about) above Ordnance datum (nearest B.M.* 317·0), *about* 80 *yards distant. Depth of well from curb* 165 *feet, sunk entirely in the middle chalk. Information collected by* Mr. H. G. Fordham, F.G.S., *from Mr. John Pearce, who died at an advanced age in May* 1887. *The mean monthly level and the mean height for the year are calculated by* Mr. H. G. Fordham. *The rainfall at Royston was furnished by* Mr. Hale Wortham.

—	1864	1865	1866	1867	1868	1869	1870	1871	1872	1873	1874	1875
January . . .	2	7½	30	42	36	20	28	6	11	51	29	12
February . . .	8	7½	47	56	46	35	36	11	14	60	28	13
March . . .	8½	9	59	60	51	55	39	12	22	69	27	15
April . . .	14	17	54	61	51	57	46	14	26	—	27	14
May . . .	19½	17	54	61	49	55	42	17	40	62	27	15
June . . .	24½	15½	50	60	43	53	37	18	42	57	24	16
July . . .	20	10	48	56	36	51	30	18	42	54	19	16
August . . .	12	9	43	50½	31	45	25	18	37	48	15	16
September . .	6	7	40	48	28	42	20	14	33	45	12	17
October . . .	9	11	38	45	24	38	16	12	28	36	10	15
November . .	7	15	33	42	21	34	14	9	25	33	10	16
December . .	8	26½	33	47	20	30	10	10	25	—	11	40
Mean level for year .	11	12¾	44	52¼	36¼	43	28½	13¼	28¾	51½	20	17
Rainfall at Royston in 1863—17·87	16·67	29·33	26·48	24·86	22·62	24·56	17·16	19 07	28·52	21·09	17·79	26·36

—	1876	1877	1878	1879	1880	1881	1882	1883	1884	1885	1886	Mean '64-'86
January . . .	—	51	48	48	61	—	68	63	62	20	32	34½
February . . .	40	57	54	60	54	69	69	—	—	18	48	39½
March . . .	48	66	57	69	57	72	69	—	—	19	51	44½
April . . .	57	58	54	72	57	78	68	75	57	27	51	47
May . . .	51	52	53	—	54	75	—	—	—	27	51	43
June . . .	49	51	54	78	53	72	66	—	—	30	57	45¼
July . . .	50	60	52	75	48	69	60	66	48	30	54	44
August . . .	42	57	48	80	49	68	—	—	42	22	51	38½
September . .	39	51	43	78	48	57	48	—	36	22	45	35¼
October . . .	36	48	39	73	—	51	43	63	27	21	40	32½
November . .	28	42	33	72	57	50	40	—	—	17	—	30
December . .	27	41	36	66	63	49	—	—	22	24	—	31
Mean level for year .	42½	53	47½	70	54¾	64½	59	—	—	23	48	39
Rainfall at Royston .	26·78	27·22	23·36	30·00	27·39	24·03	26·20	27·37	16·68	21·40	25·12	24·05

Appendix III.—*Borings in the Tertiaries of the Hampshire Basin.*

Communicated by the Aldershot Gas and Water Company. Collected by Mr. Whitaker.

1. Aldershot Waterworks, southern side of Boxall's Lane, half a mile south-west of St. Michael's. **1*a*.** 1878, two borings. A third made in 1881. **2.** About 250 feet above Ordnance datum. **3.** Boring 240 feet. **4.** Water level same in Nos. 1 and 2,

14 feet 2 inches and 16 feet 3 inches respectively. Level not affected by 24 hours' pumping. **5.** Daily yield 220,000; could pump more.

		Feet.
9.	Gravel and yellow clay	17
London clay	Red and yellow dirty clay (basement beds of the London clay)	110
Reading-Woolwich beds	Pot clay	5
	Light red dirty clay with sand	7
	" " clay with sand	23
	Dark clay, with thin bed of sand	5
	" " "	6
	Light and dark sandy clay	13
239½	Chalk with flints	46½

Aldershot, D. Lines, South Camp, 1856.

Communicated by the War Office to Mr. WHITAKER.

1a. Sunk in 1856. **2.** About 320 feet above Ordnance datum. **3.** Shaft 34. Bored to 500 feet. **4.** Water rose to 48½ feet of the surface.

Feet.			Feet.
	Brocklesham beds.	Yellow loam	15½
		Green sand	12½
		Grey sand	10
		Mixed green sand	6½
		Dark green sand	1½
		Streaky blue clay	3
53		Blue clay	4
	?	Black sand	15
88		Blue clay	20
	Lower Bagshot beds.	Mixed sand	22
		Stone (? only at bottom of bed)	4
		Mixed sand	1
		Mixed clay and sand	8
		Blue clay	6
		Yellow clay	1
		Sand and rock	5
		Mixed sand	1
		Blue clay	1
		Green sand	5
		Red sand	1
		Mixed sand	5
		Light (coloured) sand	2
		Blue clay	4
		Mixed clay	2
		Mixed sand	6
168		Mixed clay and sand	6

1. Alton Local Board Well, near the stables at Ashdell. Communicated by Mr. F. Crowley. Collected by Mr. W. Whitaker. **1a.** Sunk 1882. **2.** . **3.** Shaft 160 feet, boring 400. **4.** Before boring there was often 32 feet of water in the well, but it was soon pumped out, and the quantity gradually decreased. Now there is 17 feet of water, which is quickly replaced after pumping.

Feet.		Feet.
140	Chalk	140
208	Lower chalk and grey chalk	68
258 ?	Chalk marl, 50 or perhaps	80
268 ?	Chloritic marl, 10 or perhaps	15
348	Malm rock (Upper greensand)	80
498	Gault	150
540	Gault (? partly hard lower greensand)	42

Bournemouth Gas and Water Works. 1876.

Sunk and communicated by Messrs. S. F. BAKER & SONS.

			Feet.
Drift		White sand	$1\frac{1}{2}$
		Yellow loam	3
		Yellow gravel	8
		Yellow loam	$1\frac{1}{2}$
$14\frac{1}{2}$		Coarse gravel and stone	$0\frac{1}{2}$
	Upper Bournemouth marine series [Bagshot] of Mr. Gardner.	Bright red sand	2
		Yellow sand	$2\frac{1}{2}$
		Mottled clay	1
		Yellow sand (water-bearing)	$5\frac{1}{2}$
		Fine grey sand	$2\frac{1}{2}$
		Tough clay	5
		Grey loam and sand	4
		Grey sand (water-bearing)	$9\frac{1}{2}$
		Sharp grey sand	$2\frac{1}{2}$
		Veins of loam and sand	2
		Sharp grey sand (water-bearing)	$3\frac{1}{2}$
		Fine grey sand	$6\frac{1}{2}$
		Sharp grey sand	5
		Coarse grey sand (mineral water)	1
		Clay, very compact	8
80		Dark clay, close and tough	5

Farnborough.

Collected by Mr. WHITAKER. *Communicated by* Messrs. TILLEY & SON.

1. Waterworks. Western side of Alexandra Road, just S.E. of Alma Cottages. **1***a*. 1884. **2**. About 260 feet above Ordnance datum. **3**. 259 feet. **4**. Water level 23 feet down until July 29, 1884, when it was pumped down to 41 feet, after which the rest level was 29 feet.

		Feet.
	Gravel	7
	Brown loamy sand, rather coarse	33
	Buff sand, rather coarse (water)	33
	Yellow clayey sand, fine	8
	Green loam (turning grey when dry)	12
	Fine green sand (water)	29
	Light grey fine sand (water)	$13\frac{1}{2}$
	Dark grey clay, with some large flint pebbles	$0\frac{3}{4}$
	Green grey loam	17
	Flint pebbles, in green grey clayey sand	$3\frac{1}{2}$
$166\frac{3}{4}$	Green grey loam and sand, with pebbles	10
	Fine grey sand, with water	22
	Green sand and water	22
	Green sand, with thin layers of clay	3
	Strong green loam, with layers of clay	12
	Green sand and water	3
$259\frac{3}{4}$	London clay	31

Fordingbridge.

Collected by Mr. WHITAKER. *Bored and communicated by* Messrs. TILLEY.

1. Gasworks. By the stream, at the western end of the village. **1***a*. 1887. **2.** About 90 feet above Ordnance datum. **3.** 219 boring. **4.** Water from the sand or 125 feet rose to 13 above the ground.

			Feet.
9.		Ballast (river gravel)	14
	London clay 124½ feet.	Sand and clay	14
		Sand and pebbles	2
		Sand and clay, hard stone at base	30
		Blue clay, 6 inches of hard stone @ 24′ & 32′	32
		Sand and clay, with 17 ins. at 12 feet	33½
		Sand and water	3
		Clay	7
138½		Sand, shale, and pebble	3
	Reading beds 73½ feet.	Clay and sand	6
		Green loamy sand, with 4 ins. of stone at base	11¾
		Light brown clay	3¾
		Brown clay	2
		Coloured (mottled) clay	40
212		Dead sand	10
219		Chalk	7

Gosport.

Information collected by Mr. Whitaker.

1. Waterworks, Bury Cross. **1a.** About 1859. **2.**

3. No. 1 well. Shaft 10 feet. Larger cylinders to a depth of 83 feet; smaller to 110 feet; remainder bored. No. 1 shaft is the most easterly in the eastern engine-house; No. 2 is close by, to the N.N.W., just outside the engine-house; No. 3 is a pumping shaft, by the western engine-house; No. 4 is further west, by the north-western corner of the field, beyond the works. The water from No. 2 flows into No. 1 by a pipe. Nos. 1, 3, and 4 are connected by a conduit at the base of the shafts. **4.** Water rose to 9 feet below the surface. It was pumped down to 80 feet, and rose to 35 feet; if left for a time, would rise to 25 feet. **5.** Tested up to half a million gallons a day. **8.** Quality good. **9.** Section of No. 4 shaft, 40 feet, with bore-holes to 120, 220, and 330 feet.

Feet.			Feet.
	River drift.	Brown loam	3
12		Gravel	9
	Bracklesham beds.	Brown and grey clay	1
		Grey clay and sand laminated	10
		Light grey sand, clay, and shells	57
		Coarse grey sand and shells	22
		Brown clay	15
		Sand and peat	3½
		Clay and sand	19
		Light-coloured sand	4½
		Clay with sand	22
		Hard clay	35
		Light grey sand	22
		Clay and sand, laminated	16
		Clay with a little sand	59
303		Sandy clay, with flint pebbles	5
	L. Bagshot.	Light-coloured sand, with some flint pebbles	4
320		Light-coloured sand	13
334	London clay.	Clay, sandy clay, iron pyrites	14

Milton.

Communicated by Mr. W. Hill, *of Gosport.*

1. Portsmouth Lunatic Asylum. **1a.** In 1885. **3.** Cylinders 48 feet; rest bored to 604 feet from surface. **4.** Greatest height of water 11 feet from surface.

9.

Feet.			Feet.
	Drift.	Mould	1½
		Brick earth	5
		White running sand	29
37½		Ordinary gravel	2½
	London clay.	Blue basic clay	42½
		Hard sandstone (? septaria)	3
		Blue clay and sand	23
		Hard blue clay	82
		Hard blue boulder (? septaria)	0½
		Hard blue clay	8
		Black sand	3½
		Hard sand boulder (? septaria)	3
		Dark green sand (water)	22
		Hard boulder (? septaria)	1½
		Hard blue clay	78½
		Rock with metal	1¼
		Stiff red clay	10½
		Pipe clay	1½
290¾		Brown clay (brick earth)	10
		Light red clay, with 3 inches of sand	6¾
		Black loamy sand	5½
		Dark red clay	2¾
		Grey clay	3½
		Red plaster clay	75¾
		Hard stone	1¾
		Plaster clay and slime	3
604		Chalk, with occasional flints	177

Monks Sherborne.

Collected by Mr. Whitaker.

Communicated and made by Messrs. Legrand *and* Sutcliff.

1. The Rectory, Monks Sherborne. **1***a*. 1887. **3.** Shaft 30 feet, rest bored.

9.

Feet.			Feet.
	London clay.	Clay with septaria	30
35		„ „ shells	5
	Reading beds.	Mottled clay	25
		Sandy clay	16
		Mottled clay	9½
		Hard clay	14½
		Black sand	2
130		Chalk with flints	28

For numerous Hampshire wells of less importance, see Paper by Mr. Whitaker in the 'Papers and Proceedings of the Hampshire Field Club,' No. III. 1889.

Report of the Committee, consisting of Dr. H. Woodward (*Chairman*), Mr. J. Starkie Gardner (*Secretary*), *and* Mr. Clement Reid, *appointed for the purpose of exploring the Higher Eocene Beds of the Isle of Wight.* (*Drawn up by the Secretary.*)

The anticipation that varied and well-preserved plant remains would be obtained from among the mottled clays of the Osborne series has not been realised. Mr. Clement Reid and myself searched them both in the

east and west end of the Isle of Wight, and were unable to find any bed in which plant impressions were either distinct or varied, and those we obtained were merely reeds and the so-called cinnamon leaves common to so many of the tertiary floras. It seems that we must definitely recognise that the Oligocenes in England were deposited under conditions that did not permit the accumulation in them of those masses of forest *débris* so characteristic of almost every stage of our Eocenes. These latter were the direct deposits of rivers of large volume, which swept down leaves, flowers, fruit, seeds, twigs, bark, stipules, and every organ shed naturally by forest trees, their undergrowth and parasites, which overhung the river banks, or were carried to them by wind. The only absentees are the fruits without buoyancy, and the tender herbaceous or heavy succulent leaves, which wither on the stem, or decay very rapidly in water. The lagoons or shallow estuarine water of the Oligocene bore no such spoils from distant woods, and scarcely did their sluggish currents transport and deposit the remains of the vegetation proper to their swampy shores or islets. These drifted remains are found in patches, which some accident has kept here and there in an unusual state of preservation, and it is by the discovery of these that our knowledge of our Oligocene flora is, as a whole, extended. One or two species are usually found occupying them to the exclusion of all others, and their discovery is so fortuitous, and destruction so rapid, that we can only look to local collectors to rescue them. Mr. A'Court Smith, and more recently Mr. Colenutt, have been particularly successful in localities that were previously regarded as almost barren. The floras of the Hamstead beds, and of the Bembridge marls, rich in ferns, pines, Doliostrobus, large palm leaves, Engelhardtia, Myrica, &c., have already been described in previous reports. We now find that the Osborne flora contains Doliostrobus, Athrotaxis, Myrica, Cinnamon, reeds, palms, &c., and in no way differs from that of the rest of the Oligocenes, which probably underwent but little change from beginning to end.

In looking over the Hamstead beds Mr. Clement Reid discovered some layers crowded with a new fruit, about the form and size of a damson stone, though completely flattened, and probably of a leathery rather than woody texture. We were also fortunate enough to discover a large patch of splendidly preserved Athrotaxis (*Sequoia Couttsiæ*, Heer) partly in clay and partly in concretionary sand. This fortunately yielded cones in good preservation, and which it was possible to dissect. They are identical with the Hordwell specimens described in a former report, and do not belong to Sequoia, but distinctly to Athrotaxis. None of the specimens previously known from the Hamstead beds showed the structure of the cones, and it is remarkable that even in first describing the species from Bovey Tracey, as *Sequoia Couttsiæ*, Heer did not allude to the internal structure of the fruit, by which alone Sequoia can be separated from Athrotaxis.

I have taken the opportunity to reinvestigate the grounds on which the highest member of the Isle of Wight Oligocene and the Bovey Tertiary basin were correlated. As a result I am able to place a fine series of the so-called *Sequoia Couttsiæ* from the two localities side by side, and find that their correlation is due to a case of mistaken identity. On a cursory examination the great similarity between the foliage and cones of the two series from Hamstead and Bovey is striking, but on closer inspection we see that the resemblance in the foliage is confined to the most slender

shoots, and that even in these the tiny leaves are less rigid and of less substance in the Hamstead specimens. These annual shoots are in both cases invariably simple and shed in the greatest profusion. The stouter branches are in the Hamstead examples densely clothed with short, falcate, needle-like leaves, whilst those of similar substance in the Bovey species are covered with scale-like leaves. The woody axis of the former is also relatively much more slender, and the articulated base does not broaden into a ball-like joint. In fact, the similarity in the foliage does not extend beyond the annual shoots, the permanent foliage being acicular in the one case, and imbricated in the other. The comparison of the fruit is more difficult owing to the fact that the Bovey cones are compressed to the thickness of millboard, the Hamstead cones are compressed to about a quarter of their original diameter, and the Hordwell cones are uncompressed. The Bovey cones consisted, it appears, of fewer, larger, and more tender scales, and the internal structure of the cone is quite different. The Bovey species may in fact be a Sequoia, while the Isle of Wight species can only be an Athrotaxis.

So far these might be considered as mere variations of one species, but among the Bovey remains are somewhat comma-shaped and very flat seeds, margined with stout narrow wings, which Heer states he found lying *in sitû* under the scales of the cones. These are not only totally absent at Hamstead, but their place is taken by a small, uncompressed, crustaceous and wingless seed. I have not found them *in sitû*, for the cones are opened, but they are scattered around the cones, and even among the scales, as if scarcely washed out, and appear as if they would exactly fill the ovaries. The seeds of the three recent species appear all to be bilaterally winged, but assuming the associated seeds in each case to belong to the coniferæ, the difference would constitute them distinct species. A cone, recently described by Ettingshausen, from the Australian Tertiary, and very unnecessarily placed in the genus Sequoia, is hardly distinguishable. It is scarcely necessary to allude to the danger of describing Tertiary Conferæ from foliage, as we have seen in former reports, that this, in spite of its apparent identity, may belong to many different genera; but the transfer of this conifer from Sequoia to Athrotaxis modifies considerably our former ideas of the aspect of the vegetation, for we have, in place of hills clothed with trees of the imposing stature of Sequoia, better known perhaps as *Wellingtonia gigantea*, merely the riverside bushy conifers of Tasmania.

Further than this, the identification of the two species as one by Heer had much to do with the equally erroneous correlation of the Bovey basin with the Hamstead beds. In each deposit there are a few very characteristic and easily identifiable plants, particularly certain well-marked fruits. Chief among these at Bovey are the fruits known as Anona, which abound at Bournemouth, and have never been seen in the Hamstead beds. On the other hand, at Hamstead the chief fruits are Carpolithes globulus and Cyperites Forbesii, never found at Bovey, Nymphæa Doris, which I have not compared, and Carpolithes Websteri, which is undoubtedly common to both localities. This fruit first appears away from Bovey, in the Lower Headon of Hordwell. Among Bovey leaves we have Osmunda lignitum, abundant at Bournemouth, but quite absent from the Isle of Wight Oligocene, and Goniopteris Stiriaca absent from both. Lastly, the very curious palm spines, which abound at Bovey and Bournemouth, are never seen in the Hampshire Oligocenes. There

are probably no other plants common to the Bovey and Isle of Wight beds, and certainly none that do not also range down into the Bournemouth Eocene.

The evidence of the Osmunda, Palmacites, and Anona must outweigh that of Carpolithes Websteri, even if we attach no importance to the absence at Bovey of the rest of the characteristic Hamstead and even Bembridge fossils. In the absence of the C. Websteri there would be no reason for not absolutely assigning the Bovey basin to the Bournemouth or Middle Eocene age, but as matters stand, it would perhaps be safest to regard the Bovey formation as a mass of coarse river grits, enclosing in places some considerable patches of lignite, of probably Bracklesham age, but certainly not newer than Lower Headon. As a mass they are entirely indistinguishable from the Lower Bagshot beds of Wareham, and certainly cannot be regarded as in any sense lacustrine, unless the river deposits of the Middle and Lower Bagshots are to be assigned a similar origin.

Third Report of the Committee, consisting of Mr. R. ETHERIDGE (*Chairman*), Dr. H. WOODWARD, *and* Mr. A. BELL (*Secretary*), *appointed for the purpose of reporting upon the 'Manure' Gravels of Wexford.* (*Drawn up by* Mr. A. BELL.)

THE writer greatly regrets not being able to complete the final report on the Wexford 'manure' gravels and other deposits in time for the present meeting of the Association. Since the last (second) report the explorations carried out in the area of the gravels, in Ballybrack, Balscaddin, and Balbriggan Bays, in Larne Lough and the vicinity, and Portrush, have so much augmented the material accumulated in years past that a postponement till next year is requisite in order that the facts may be properly assimilated and the specimens accurately named.

The exigencies of building and road-making have practically obliterated the most prolific portion of the drifts in Ballybrack (or Killiney) Bay and the deposit at Portrush, the only traces of the shell-bed at the latter place occurring between the rocky masses on the shore above high-water mark. Fortunately, previous to these operations a quantity of material was obtained by the reporter, and a list of about 120 species will be given in the sequel, wherein a brief notice of the principal deposits will be found, with lists of fossils obtained by the writer and previous observers. The line of research to which an examination of the fossils has led the writer is to the effect (1) that the so-called Lower, Middle, and Upper drifts in Ballybrack Bay have no connection whatever with the equally so-named deposits in the English and Welsh areas, but are a continuation northward of the Cotentin-St. Erth-Wexford sea-bed referred to in the second report, 1888, further traces of this extension obtaining in the glacial clays of the Isle of Man, *Nassa reticosa*, among other Pliocene mollusca, occurring in the northern portion of the island.

Coeval with the Pliocene fauna of Wexford, Ballybrack, and the Isle of Man are numerous species of northern origin, and examination of these suggests a Scandinavian rather than an American or Greenlandic origin—a suggestion intensified by the presence of a true Scandinavian fauna in several parts of the Scottish lowlands from the Clyde to the Forth and

the eastern side of Scotland; and it is not perhaps too improbable to suppose that the Pliocene shells obtained by Mr. T. F. Jamieson in Aberdeenshire came by this route rather than from the Suffolk crag-beds. From the absence of the Pliocene fauna northward of the before-quoted localities on the Irish coast and Manxland, the writer is of opinion that the Irish Channel was closed when the strata at these places were being accumulated, and

(2) That the Severn drifts from Worcester northwards into Lancashire are of much later date, not originating till the south of Ireland was separated from the continent. And lastly, that the faunas obtained both in England and Ireland, near Dublin and Wicklow, at elevations of 1000 feet and more, are 'remainie' and not in their original habitat.

An examination of the gravelly and shelly sand dredged from the Turbot bank in the Irish Sea has long convinced the writer that the accumulation is in the main of post-glacial age, intermixed with a few recent forms, easily distinguished from the older species by their appearance. The material is very rich in other groups *than* the molluscan, catalogued already by Mr. Hyndman. Of all these I propose giving a list.

It may be well to say that the matter first examined was sent to the writer some years back by Mr. E. Waller, who worked with Mr. Hyndman on the mollusca; and, secondly, from a quantity of Mr. Hyndman's own washings, placed at my disposal by Mr. S. A. Stewart, of Belfast.

Second Report of the Committee, consisting of Professor FLOWER (*Chairman*), Mr. D. MORRIS (*Secretary*), Mr. CARRUTHERS, Dr. SCLATER, Mr. THISELTON-DYER, Dr. SHARP, Mr. F. DUCANE GODMAN, *and* Professor NEWTON, *appointed for the purpose of reporting on the present state of our knowledge of the Zoology and Botany of the West India Islands, and taking steps to investigate ascertained deficiencies in the Fauna and Flora.*

THIS Committee was appointed in 1887, and reappointed in 1888. At a meeting held on December 5, 1888, it was decided to invite the cooperation of Dr. Günther, F.R.S., a member of the Subcommittee appointed for a similar purpose by the Government Grant Committee of the Royal Society, and Colonel Feilden, of the Army Pay Department, at that time acting as Local Secretary to the Committee at Barbados.

The services of Mr. G. A. Ramage were retained as collector at Dominica and St. Lucia, and several collections were received from him during the past year. Owing to ill-health Mr. Ramage returned to this country in June last, and he has now retired from the post of collector to the Committee. Mr. F. DuCane Godman has generously assisted the work of the Committee by sending out, at his own expense, the well-known naturalist and collector, Mr. H. H. Smith, to the Island of St. Vincent, to make collections in as many branches as possible of Natural History. These collections have not yet reached this country, but it is anticipated that they will prove of considerable value.

Colonel Feilden obtained numerous botanical and zoological specimens in Barbados and the neighbouring islands. He has published a paper on the reptiles, and another on the birds; papers on the mammalia and land mollusca will follow. He also obtained a living specimen of the

green monkey of Western Africa which has become feral in Barbados (*Cercopithecus callitrichus*). This was presented by the Committee to the Zoological Society of London.

Dr. H. A. Alford Nicholls, F.L.S., Local Secretary to the Committee at Dominica, has rendered valuable assistance, and he will be engaged for six weeks this autumn in exploring Montserrat and the isolated rock called Redonda, which is a dependency of Antigua.

The particulars of the collections received during the past year are as follows:—

Zoology.—The zoological specimens obtained by the Committee up to June 1889, including those collected by Mr. Ramage in Dominica and St. Lucia, have been placed in the hands of specialists for examination and determination. Mr. Oldfield Thomas has determined the mammalia, Dr. Sclater the birds; Dr. Günther has published a paper on the reptiles, Mr. E. A. Smith three papers on the mollusca, Mr. R. I. Pocock two on the myriopoda and crustacea, and Mr. Kirby one on the phasmidæ.

Botany.—The botanical specimens collected by Mr. Ramage in Dominica and St. Lucia, up to May 1889, have been determined at Kew; the flowering plants by Mr. R. A. Rolfe, the ferns by Mr. J. G. Baker, and the cellular cryptogams by Dr. Cooke and Mr. C. H. Wright.

From Dominica about 394 species were received, of which (excluding the cryptogams) about 40 could only be provisionally determined; and of these a few, perhaps about half, are probably undescribed. The great majority belong to already well-known species, most of which were previously known from the island.

From St. Lucia about 189 species have been sent, of which (excluding the cryptogams, as before) over 30 were not determined, and possibly about half of these may prove to be undescribed. This island was less completely known than Dominica, and several additions to our knowledge of its flora have been made by Mr. Ramage. During the working up of the collections a strong affinity with Dominica, and perhaps still more so with Martinique, has become apparent. From the latter island large collections are well represented at Kew, though the materials have never been thoroughly worked up.

The specimens which it was not found possible to determine belong for the most part to large genera of woody plants, as guttiferæ, leguminosæ, myrtaceæ, myrsineæ, laurineæ, and a few others, which renders it the more probable that a fair proportion of them may prove undescribed.

The number of novelties is perhaps not so great as was originally expected, and this may arise either from the ground having been worked over before, or, what is perhaps more probable, from the fact that a considerable uniformity prevails in the flora of this chain of islands, with a corresponding paucity in endemic types.

The Committee would draw particular attention to the botanical and zoological bibliography of the Lesser Antilles prepared under their direction, and published as an appendix to the Report for 1888. This bibliography has been widely distributed in the West Indies and in Europe, and has proved of considerable service in carrying out the objects for which the Committee were appointed.

The Committee recommend their reappointment, with the addition of those gentlemen who have co-operated with them in the work of the past year. They further recommend that a grant of 180*l.* be placed at their disposal.

Second Report of the Committee, consisting of Professor E. RAY LANKESTER, Professor A. MILNES MARSHALL, Mr. A. SEDGWICK, *and* Mr. G. H. FOWLER (*Secretary*), *appointed for the purpose of investigating the development of the Oviduct and connected structures in certain fresh-water Teleostei.*

THE Secretary regrets that, owing to the failure for a second year of several fish-hatching establishments to supply in any quantity ova and fry of the special fish required for this purpose, it has not been possible to carry out the investigation. The money granted for apparatus and similar needs has therefore not been expended.

Report of the Committee, consisting of Dr. P. L. SCLATER, Professor RAY LANKESTER, Professor COSSAR EWART, Professor M. FOSTER, Mr. A. SEDGWICK, Professor A. M. MARSHALL, *and* Mr. PERCY SLADEN (*Secretary*), *appointed for the purpose of arranging for the occupation of a Table at the Zoological Station at Naples.*

IT is the pleasant duty of your Committee to report that the Zoological Station maintains its course of steady progress and success, each year being marked by some improvement in the building or the development of some new line of research, whereby additional advantages are afforded to those who have the privilege of working at the Station.

Your Committee have also the satisfaction of drawing attention to the fact that the table at their disposal has been fully occupied during the whole year, four naturalists having been accommodated since the last report. Indeed, for the long period of nearly five months two tables were placed at their disposal through the kindness of Professor Dohrn, to avoid disappointment on the part of those who wished to work at Naples at a particular time of year. Your Committee desire to place on record their appreciation of Professor Dohrn's liberality and readiness to oblige in every way possible.

The completion of the chemical department of the new physiological laboratory, under the direction of Dr. von Schroeder, was announced in last year's report. Unfortunately, the state of Dr. von Schroeder's health renders him unable to remain in Naples. He will be succeeded by Dr. Herter, of Berlin, who will assume the duties of Director of the laboratory in October, at the end of the hot season. This department is now fully equipped with instruments, chemicals, &c. In the experimental department of the laboratory the rooms are now being finished, and the Directorate hopes that this department will be ready and in working order during the course of next year.

Investigations having a practical bearing on fishery questions are being actively continued. The results are watched with great and appreciative interest by the Italian Ministry of Agriculture and Commerce. on account of the many contradictory opinions in vogue and the continual agitation for and against the present fishery laws and regulations. In furtherance of these inquiries Professor Dohrn now proposes to examine

extensively the 'take' of the Neapolitan trawlers, with the view of testing the results already obtained. In the new physiological laboratory particular attention will be paid to the preservation of fish for the purposes of food—a question which is of great importance in the Mediterranean, especially during the hot season.

In the Bacteriological Laboratory all the available places have been occupied during the year. Attention is drawn to the importance of the investigations carried out by Professor de Giaxa,[1] of Pisa, and Dr. F. Sanfelice,[2] of Naples, which have recently been published. Professor de Giaxa's conclusions are: 1. Sterilised sea-water—independently of the common micro-organisms it contains, and perhaps independently of the changes produced by the presence of organic and mineral matters coming from sewers—is an excellent nutritive medium for the reproduction of the bacilli of cholera, carbuncle, typhus, and of *Staphylococcus pyogenes aureus.* These micro-organisms can reproduce and propagate in it to a considerable degree. 2. In non-sterilised sea-water the reproduction of the above-named four micro-organisms is prevented by the competition which takes place between them and the common micro-organisms present in the water, the intensity of the influence being principally and perhaps entirely dependent on the number of the latter present. 3. The bacilli of carbuncle and cholera introduced into the stomach of fishes were destroyed after a short time. Their destruction is due partly to the gastric juice and partly to the competition which takes place between the pathogene bacilli and the common bacteria existing in the stomach and intestines of fishes. In like manner the bacilli of carbuncle and cholera do not live in molluscs.

Dr. F. Sanfelice limited his researches to the bacteriological analysis of the sea-water in certain localities on the east and west coasts of the Gulf of Naples. He has examined the water in proximity to sewers, and at distances of 100, 200, 300, and 400 metres. The result of counting the colonies on gelatine plates demonstrated that there is in the vicinity of the coast a great number of micro-organisms, and that this number diminishes sensibly as the distance from the shore increases. The number is more considerable where the larger sewers open, and it diminishes very sensibly in the open water. Other papers bearing on these questions will be found in the list of publications for next year.

The negotiations with the Spanish Government, referred to in last year's report, have resulted in three tables having been secured by the Ministries of Marine, Public Instruction, and the Colonies, respectively. Two naval officers have already completed their course of instruction, and several other officers and naturalists are expected at the Station. One of the Russian officers at present on duty in Japanese waters is making large collections of specimens, which promise to be of the highest scientific interest.

On the subject of the participation of universities and States in the advantages of the Station, together with increased privileges, and on the mode of obtaining means necessary for conducting this expensive part of the establishment, the Directorate proposes to report specially next year.

[1] 'Ueber das Verhalten einiger pathogener Mikroorganismen in Meerwasser.' *Zeitschrift für Hygiene,* vol. vi. p. 162, 1889.

[2] 'Ricerche batteriologiche delle acque del mare in vicinanza dello sbocco delle fognature ed in lontananza da queste.' *Boll. Soc. di Naturalisti,* Napoli, vol. iii. part I., 1889

The Publications of the Station.—The progress of the various works undertaken by the Station is here summarised :—

1. Of the 'Fauna und Flora des Golfes von Neapel' no monographs have appeared since the last report; but it is intended to publish during the course of 1889 monographs by Dr. Falkenberg on 'Rhodomeleæ,' and by Dr. Della Valle on 'Gammarini.'

2. Of the 'Mittheilungen aus der Zoologischen Station zu Neapel,' vol. viii., parts i., ii., iii., iv., with 25 plates, and vol. ix., part i., with 7 plates, have been published.

3. Of the 'Zoologischer Jahresbericht,' the whole 'Bericht' for 1887 has been published.

Extracts from the General Report of the Zoological Station.—The officers of the Station have courteously furnished lists (1) of the naturalists who have occupied tables since the last report, (2) of the works published during 1888 by naturalists who have worked at the Zoological Station, (3) of the specimens sent out by the Station during the past year. These details are appended, and speak for themselves as to the activity of the Station.

The British Association Table.—Four naturalists have occupied the British Association table during the past year: Mr. F. Ernest Weiss, for four months; Mr. W. L. Calderwood, for a little longer than four months; Dr. N. A. Cobb, for eleven weeks; and Mr. Arthur Willey for three weeks. All of these gentlemen have furnished reports on the nature of their investigations, which are appended.

Two applications for permission to use the British Association table during the current and coming year have been received. The Committee hope the Council will enable them to sanction these applications by renewing the grant (100*l.*) for the ensuing year. In the opinion of your Committee the assurances of the utility of the British Association table now presented fully justify them in strongly recommending the renewal of the grant.

I. *Report on the Occupation of the Table, by* Dr. N. A. Cobb.

I received in Munich early in November the welcome permission to use for a limited period the British Association table in the Zoological Station at Naples. I started at once for Italy, and with the kind assistance of the genial officers of the station was soon settled and at work.

I proposed to make some comparative studies among worms, and to pay particular attention to the affinities of the Nematodes. Abundant material was supplied me, and I soon had a collection of common annelids and parasitic nematodes ready for investigation, and next turned my attention towards the free-living marine nematodes.

Here I met a difficulty. To study these worms under the microscope one by one in a living condition seemed to me very tedious, and hardly to answer all my purposes. I wished for a large number of successfully preserved specimens for comparative study. It became apparent at once, however, that the common methods were too rough to give good results with these delicate little creatures. I resolved therefore to grapple once more with the problem of avoiding shrinkage during the process of hardening and preserving.

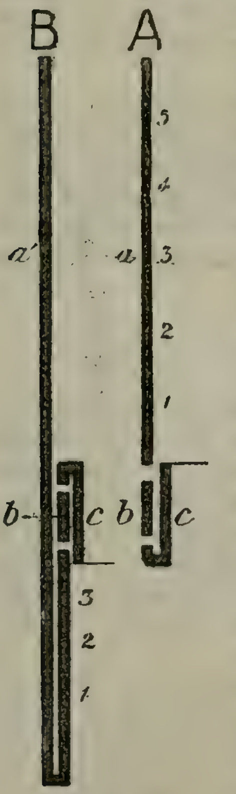
This was no new battle-field to me. A number of years ago, while at work on some delicate freshwater algæ (*Spyrogyra*), I had tried to

overcome these same difficulties, but not with perfect success. I at that time made use of osmosis, and invented several instruments, all in some degree resembling that of which Schultze has more recently given a description. The apparatus was, however, complicated, and therefore difficult to prepare as well as to use, the method tedious, and the results not altogether satisfactory.

The importance of the matter being once more brought home to me, I determined to see whether it was not possible, by some simple means, to attain the desired result, and to devote, if necessary, a long time to experiments directed towards that end. Fortunately I soon hit upon a contrivance which, while it is extremely simple, is correspondingly efficient.

Without burdening this report with an account of my more or less unsuccessful experiments, I will proceed at once to describe this simple and efficient instrument which has rendered me such good service. It is made from glass tubing, which may vary in internal diameter from 3 mm. to $\frac{1}{2}$ cm. or more. The instrument is double in its nature. If the objects are being transferred from a heavy fluid to a lighter, Form A is used; if from a light fluid to a heavier, Form B is used.

Each form consists of three pieces of tubing, bent as shown in the figures. Two of the pieces, *b* and *c*, are common to both forms. *a* and *a′* differ from each other in that *a′* is longer, and is doubled on itself below. I will call *a* and *a′ reservoirs*; *b* the *object-box* or object-cylinder; and *c* the *filter*. All are shown in position in the figures. In use the object-box is joined to the reservoir and filter by rubber tubing, which, for the sake of simplicity, is *not* shown in the figures. The termination of the filter *c* is made into a capillary tube having an internal diameter of ·1 to ·2 mm.



The object, supposed to be previously fixed in sublimate or other fixing agent, is placed in the object-box in some of the fixing fluid, and is kept in place by plugs of cotton, asbestos, shreds of linen, or other similar material. The filter is also filled with the fixing fluid, and it will be found best to insert here also a plug of cotton, otherwise particles of carmine, &c., may stop up the terminal capillary part. The filter and box are now joined together by rubber tubing, no bubbles being admitted. To avoid bubbles in the cotton, boil it, or soak it in alcohol and rinse in water.

Suppose now the object has been fixed in sublimate, and is to be mounted in balsam after straining in borax carmine. I bring the object first into 30 per cent. alcohol, a *lighter* fluid, as follows:

The box and filter, joined together as just described, are connected with a reservoir as in A. The reservoir is then filled to 1 with 5 per cent. alcohol, from 1 to 2 with 10 per cent. alcohol, from 2 to 3 with 15 per cent., from 3 to 4 with 20 per cent., from 4 to 5 with 25 per cent., and from 5 to the top with 30 per cent. By taking sufficient care these different alcohols may be allowed to flow in that they will remain distinct from one another, or they may be run in so forcibly that the whole contents of the reservoir will be a nearly uniform mixture of about 15

per cent. alcohol. Between these two extremes lies the desirable mean. Theoretically the change, in passing from the bottom of the reservoir to the top, should be perfectly gradual and uniform from 0 per cent. to 30 per cent. This would justify the name which I have given the instrument, 'The Differentiator,' and, in fact, the approximation to the theoretical perfection may be so close a one that I retain the name first suggested by the mathematical analogy.

Even before the reservoir is full the pressure causes a slow flow through the filter, and, drop by drop, the whole contents filter through, and the object is thereby slowly transferred to 30 per cent. alcohol. Hurtful diffusion currents are completely avoided.

The rate of flow is governed by the size of the capillary part, the tightness of the plugs, and the *inclination of the instrument*. The first two of these factors are approximately controllable, the third *exactly* so. The rate of flow, and therefore the period of time occupied by the change, may consequently be accurately regulated. I find it best to prolong the period to ten hours in the following cases: Sublimate to 30 per cent.; 30 per cent. to borax carmine; borax carmine to 50 per cent.; 50 per cent. to 70 per cent.; 70 per cent. to 90 per cent.; 90 per cent. to absolute; absolute to $\frac{1}{2}$ turpentine; $\frac{1}{2}$ turpentine to turpentine; turpentine to dilute balsam. It is well to bear in mind that at length the flow is slower than at first, owing to a decrease of pressure, though the difference is not so great as might be expected (on account of the influence of the capillary tube). This forethought will lead to the insertion of rather greater quantities of the heavier fluids than would otherwise be the case.

The next change, from 30 per cent. alcohol to borax carmine, a *heavier* fluid, is accomplished in a similar manner, but by means of reservoir a'. This latter, held in a vertical position, is filled halfway to the top of the short arm with carmine, and the whole of the carmine is then sucked into the long arm, which is now hermetically closed at the top, either with the finger or (better) a small stopper. The now empty short arm is filled up as follows: Make three mixtures—

No. 1.	Equal parts carmine and 30 per cent. alcohol .	50 per cent. carmine
No. 2.	" " No. 1 " " " .	25 " "
No. 3.	" " " " carmine . . .	75 " "

Fill the short arm up to 1 with No. 3, from 1 to 2 with No. 1, from 2 to 3 with No. 2, and from 3 to the top with 30 per cent. alcohol. Now move the box and filter from a to a', avoiding bubbles, and finally remove the hermetic seal from the long arm of a' and fill it up with carmine. The flow begins as before, but the object is now transferred from the *lighter* 30 per cent. alcohol to the *heavier* borax-carmine, a change which would be impracticable in Form A.

The differentiator being now described, it remains to add some suggestions brought to mind by my experience with it:

1. Caoutchouc is soluble in turpentine, ether, &c. In case any of these fluids are used the caoutchouc tubing should be fresh and thick, and, further, be firmly tied to the glass parts.

2. Small objects get lost in the cotton. If, however, each plug is done up in fine, new linen cloth, no loss will occur.

3. Notes, if plainly written with pencil, are legible even after passing through carmine.

4. In making a' the glass tubing must be gradually and thoroughly heated in a good Bunsen flame. The capillary termination of the filter is

made by heating the tubing and pulling out to arm's length. Most of the narrow part thus made is broken off and thrown away, only two to three inches of it being allowed to remain intact. This is bent at right angles with the original tubing in a low alcohol flame, and then again drawn out in the alcohol flame to capillary size.

5. All corners had better be rounded off in a Bunsen flame.

Thanks to the differentiator, I have lying on slides, ready for investigation, about 3,000 excellent specimens of free-living nematodes, about half in glycerine and half in balsam. In spite of the fact that many of the species are delicate little creatures only half a millimetre long, the shrinkage is in the strict sense of the word scarcely perceptible.

What I have said concerning nematodes applies also to such infusorians, diatoms, desmids, and mould-filaments as I have come across among my specimens (therefore killed at the same time and treated in the same manner as the nematodes).

I find that vorticella, young platyhelminthes, rotifera and infusoria, which generally defeat the process of fixation by untimely contractions, become limp and manageable with sublimate, &c., if they are first changed to 30 per cent. alcohol (or weaker) in the differentiator.

The instrument may be found of general application. It recommends itself on account of its simplicity. Anyone can make it in a few minutes' time.

I shall make the results of my studies while at Naples the subject of a paper shortly to be published.

I desire to take the opportunity at the end of this report to express my hearty thanks to the Committee of the British Association for the profit and pleasure I have enjoyed in the use of a table at a zoological station so happily situated and skilfully managed as that at Naples.

II. *Report on the Occupation of the Table, by* Mr. F. Ernest Weiss.

I occupied the table of the British Association at the Zoological Station at Naples from January 1, 1889, to May 1, 1889, and during the whole of my stay everything that could facilitate my work was done by the authorities. As the eggs of Sepia and Loligo, on which I had intended chiefly to work, were still scarce, I started on some anatomical investigations of *Amphioxus*, and was able to confirm the observations of Professor Lankester, published while I was still working at Naples.

Having the living material at hand, I also undertook some observations with regard to the currents of water passed through the pharynx and gill-chamber, and some physiological experiments on the absorption of food particles and on the excretion. Carmine granules were readily taken up in a finely divided state by the intestinal epithelium, and the carmine was found later in the vascular system no longer as granules, but colouring the corpuscles, and, to a certain extent, the liquid.

This fact enabled me to confirm the statements of Schneider, which, according to Professor Lankester, needed confirmation—namely, that the dorsal aortæ send off lateral vessels both into the primary and into the secondary bars of the pharynx.

With regard to the excretion I did not arrive at any definite results, owing partly to the lack of time, as Dr. Eisig pointed out that in the case

of many of his experiments on Capitellidæ the excretion of carmine lasted for several months. The Amphioxus, indeed, retained the pink colour they assumed after feeding with carmine in undiminished intensity during several weeks. The fact, too, that the carmine was no longer in the form of granules would render it less easily detected unless in large quantities.

In the cœlomic funnels, described by Professor Lankester as probably excretory organs, I was unable to detect the presence of carmine, and these organs probably excrete directly from the cœlomic fluid in which I discover any carmine, whereas the vascular system possibly excretes through the highly vascular gland in the pre-oral region.

Later on in my stay I had the opportunity, with a plentiful supply of material, to observe the segmentation stages, especially of Loligo and Sepia, but unfortunately could not obtain any eggs of Octopus.

I also examined the cœlomic fluid of a large number of Chætopod worms, with special regard to the excretory particles contained in the cœlomic corpuscles.

I had, too, the opportunity of extending my knowledge of the general marine fauna, and especially of the Pelagic forms in which the Bay of Naples is so wonderfully rich. Such a general study is, perhaps, for younger students of Biology of greater importance when occupying a table at the Zoological Station than the more specialised research work, especially on the first visit to a marine station.

By no means the least important feature of my stay at Naples was the opportunity it gave me of intercourse with such eminent workers as Dr. Dohrn, Dr. Eisig, and Dr. Mayer, from whom no student could fail to gain in experience, through their readiness to give counsel and advice. Lastly, the opportunity of discussing subjects of biological interest with the students of other nations, representing as they do at Naples almost all the schools of Europe, makes a stay at the Zoological Station conducive to a widening of our point of view, and is of the utmost importance.

For the vast amount I have gained during my stay at Naples in knowledge, experience, and I may say also in friends of kindred interests, I desire to express my thanks to the Committee of the British Association, who, in granting me the table, conferred upon me so lasting a benefit.

III. *Report on the Occupation of the Table, by* Mr. W. L. Calderwood.

Having had the privilege of working at the British Association table in the Zoological Station at Naples, I have now the pleasure to report on the results I have obtained. At the outset I must thank Prof. Dohrn for his kindness in making the necessary arrangements, and likewise his staff for their assistance during my work.

I commenced, first of all, a general study on those animals which, easily obtained in the Mediterranean, are not to be found in the colder seas surrounding the British Isles.

After passing over much well-trodden ground in the Invertebrate Group, I turned my attention to fishes, and eventually concentrated my work particularly upon the so-called Flying Gurnard, *Dactylopterus volitans.* In the study of this fish, therefore, the most of my four months' stay was taken up.

The head of *Dactylopterus volitans* is superficially covered by a complete bony layer. In the natural condition this shows no appearance of sutures, and is produced backwards, dorsally, beyond the region of the skull. Here it bifurcates, each branch forming a large flat plate resting on what is popularly known as the 'shoulder,' and each ending in a flattened spine. For convenience I have called these the dorsal plates. After maceration in a very strong solution of caustic potash this layer is separable into distinct areas, and can be removed, leaving the true skull bones exposed beneath. It is then seen to be a true sheath arranged with a view to strength.

Each superficial suture is above the body of a true bone, and each deep suture in the skull proper is below the body of one of these areas.

Of the skull itself the occipital arch is the only one deserving of special attention. It is peculiar, but will be better understood after examining the swimming-bladder itself. The vertebral column is already well known to be peculiar. As in *Fistularia*, a Japanese pipe-fish, the first four vertebræ have coalesced so as to form a rigid tube; their neural spines have also united to form a vertical plate. I can gain no information concerning *Fistularia*, but in *Dactylopterus* it appears to me that this peculiarity is subservient to the uses of the swimming-bladder, just as I think the dorsal plates are. Both give rigidity and strength to this segment of the fish.

The swimming-bladder, so far as I am aware, has a unique position, inasmuch as it is not situated below, but above, the vertebral column, not forming part of the abdominal contents, but situated dorsally in a special cavity of its own. When the abdominal cavity is opened ventrally, and the viscera removed, only the ventral surface of the bladder is seen, forming part of the dorsal boundary of the cavity. Seen from this point of view, it is formed of a broad central portion, white and tendinous, and of two lateral portions, strongly muscular.

The kidneys overlap the swimming bladder posteriorly, and the œsophagus and pericardial cavity partially obscure its anterior end.

On removing the abdominal walls so as to obtain a view of the side, and also of the back, the lateral muscles are seen to continue upwards, to curve inwards towards the median line, to be reflected downwards on each side of the vertical neural plate, and finally to become attached to the bodies of the vertebræ, whose spines go to form that plate.

Leydig [1] gives a short description of the swimming-bladder of *Dactylopterus*, the result probably of a somewhat cursory observation, as he seems to have had the impression that there was only one large muscle covering the dorsum of the bladder. But, as the four coalesced vertebræ of the spinal column necessarily intervene, it will be at once evident that the bladder is here partially divided into equal portions, forming, as will be seen later, its two primary divisions. Günther [2] recognises the bladder as being divided into 'two halves, each having a large muscle.' A lateral view of one of those muscles gives an elliptical outline, the long axis running, from the posterior end, forwards and slightly upwards. Tracing, however, the dorsal surface forwards, and on its inner or median aspect, we find that here there is, on each side, a secondary portion concealed immediately below the dorsal plate before mentioned. Carefully scraping away this plate, it is seen to be composed of an extremely thin

[1] *Lehrbuch der Histologie.* [2] *Introduction to the Study of Fishes.*

transparent membrane, we might say merely the lining membrane to the bony cavity in which it is contained. In shape it is triangular, the base being towards the median line of the body; the dorsum, on account of its close relation to the dorsal plate, is necessarily flat; the ventral aspect or floor is somewhat spoon-shaped, being enclosed in a prolongation backwards of the exoccipital bone. This prolongation also forms the lateral margins of the cavity, and is united to the dorsal plate above.

This secondary portion of the bladder is therefore entirely surrounded by bone, excepting the foramen, by which it posteriorly communicates with the primary portion.

Making now a vertical longitudinal section through the primary portion of one side, so as to obtain a view of the interior, we see that centrally there is a thin membrane perforated in one place by a foramen, dividing it transversely into two. Immediately behind this membrane there is a tunnel seen passing in a transverse manner from one primary division to the other; this passes below the vertebral column, and is the only portion situated below. In this way, therefore, the bladder, instead of being composed only of two, is seen to be divided into six compartments.

A. Moreau[1] describes an interesting experiment which he made on *Trigla hirundo*. Observing two nerves passing to the swimming-bladder, having their origin below the pneumogastric, near to the first dorsal pair, he stimulated them with electricity, and produced the characteristic grunting sounds of the Triglidæ.

On studying the bladder, he found in the dividing septum (which he calls the diaphragm) radiating and circular muscular fibres forming a kind of sphincter round the central circular opening.

On removing the posterior end of the bladder, and stimulating again, although naturally no sound was produced, this sphincter was seen to contract. He therefore concludes that the sound is produced by vibrations caused by the contraction of this diaphragm.

While killing two of my specimens of *Dactylopterus* sounds exactly similar to those of the Gurnard were distinctly heard, and simultaneously with each sound a distinct contraction of the bladder could be felt from the exterior. These contractions were quite independent of any movements of the mouth or operculum. After examining the diaphragms of *Trigla hirundo*, *T. lyra*, and *Dactylopterus*, and finding their structures all exactly similar, I am inclined to support Moreau's conclusion.

Studying now more carefully the bones forming the cavity for the secondary portion, we find that from the basi-occipital the neural arch slopes forwards, while the exoccipitals have branches projecting backwards and upwards, spreading out superiorly so as to form a broad basis of attachment to the dorsal plate. As has been already noticed, these processes form the floor and external margin of the cavity. The basis occipital with its forward projection forms the boundary. The inner side is formed by the paroccipitals, and the roof by a joint arrangement of supraoccipital and parietal.

The situation of this secondary portion, surrounded as it is by skull bones, made me at first apprehend a connection with the ear, as is the case in some Siluridæ, Characinidæ, Cyprinidæ, and Gymnotidæ,[2] and

[1] *Sur la Voix des Poissons.*

[2] Günther: *Introduction to the Study of Fishes*, 'Organ of Hearing and Air-Bladder.'

also as observed by Professor Parker in the Red Cod, *Lotella bacchus.*[1] But after the most careful dissection the bladder still appeared to end blindly, and without coming in contact with any modified bones which might serve as ossicles of the auditory apparatus.

I may here mention also that there is no communication between the bladder and œsophagus.

The histology of the bladder, although interesting in many respects, cannot be entered into here, but must form the subject of a future paper.

The flying powers of *Dactylopterus* are by some, I find, called into question. Making inquiries about such habits of the fish as are known, I am informed by Signor Lo Bianco, of the Naples station, that it is met with in the Bay at a depth of from 20–60 metres, say 10–30 fathoms, but is never seen on the surface.

In the literature on the subject there are two or three very old notes, merely saying that the fish flies or has been seen flying. Then Möbius, who has written largely on the flying powers of *Exocœtus*, describes its flight when discussing whether flying fish move their wings or not. He compares the flight to that seen in many grasshoppers, 'which raise themselves from the ground with a spring, and, eking out their momentum as much as they can by buzzing their wings, fall to the ground after a short flight.'

Moseley[2] refers twice to their flight, the second time when he was collecting amongst the weed of the Saragossa Sea. This instance seems to me to be conclusive, I therefore quote it. 'I watched these little flying fish fly along before the boat at a height of about a foot above the water for distances of 15 or 20 yards, and I chased them and caught one or two with a hand-net amongst the weed.'

From a study of the young *Dactylopterus*, i.e. the fish formerly known as *Cephalacanthus*, it is evident that only the adults can have the power of 'flight.' The smallest specimen I had an opportunity of examining was $1\frac{3}{4}$ inches. The pectorals, when placed along the side, reached to a level of the second dorsal fin-ray—a fin so short as to be quite insignificant as a flying organ. In the full-grown fish the pectorals, when placed in the same position, reach quite to the base of the caudal fin, and when spread out in an extended position form huge, beautifully-coloured wings. This condition is approached to some extent in *Trigla lyra*, a gurnard not uncommon in British waters. Although very closely allied to the Triglidæ, Günther does not include *Dactylopterus* in that genus, but places it in the Cataphractidæ, a small group represented on our shores only by the Pogge, *Agonus cataphractus*, a fish living amongst the weeds at the bottom.

Without doubting the flying powers of *Dactylopterus*, I am inclined to think that it is also in the main a non-pelagic fish. The peculiar structure and position of the swimming-bladder, amongst other things, point, I think, in this direction.

The bladder of the gurnard is well known—thin-walled and non-muscular—situated in the dorsum of the abdominal cavity. When a gurnard is brought suddenly to the surface it almost invariably turns belly upwards and swims or floats in this position. This is caused, I think, by the sudden expansion of the contained gas, consequent upon

[1] Parker, T. Jeffrey: *Trans. N. Z. Instit.* vol. xv., 1882, p. 234.
[2] Moseley: *Notes by a Naturalist on the 'Challenger,'* p. 562.

the relief of pressure. The line of least resistance is naturally the ventral one, therefore the bladder expands downwards amongst the abdominal viscera. If the expansion has been too great, the bladder is incapable of recovery, and the fish remains in this position till it dies. I have seen gurnards swim in this inverted position for several days before death ensued.

This seems to me to throw considerable light upon the bladder of *Dactylopterus*. If, let us say, to escape from an enemy, it has to make a sudden ascent and to leap out of the water, the conditions which prove fatal to the gurnard are overcome by the peculiar structure and position of the bladder. The only line of possible expansion is again towards the abdominal viscera, but it is in this direction counterbalanced by the action of the two strong muscles.

The bladder, then, being prevented from expanding when the pressure from the surrounding water is suddenly removed, the high dorsal position of the secondary portion becomes of the greatest possible advantage.

For, comparing *Dactylopterus* with *Exocœtus*, we find that it has not got, in cross section, that deep elliptical circumference, nor is it provided with small keels to aid its balance when in the air. A transverse section of *Dactylopterus* at any part of the body shows an almost circular outline. Therefore the swimming-bladder, placed, as it is, right up in the back, must be of the greatest service in enabling the fish to maintain a proper position when in the air.

Concluding, I would sum up therefore as follows: that *Dactylopterus*, although retaining its gurnard shape and habit of life, has, nevertheless, taken to the air as a means of escaping from its enemies. To compensate for its somewhat clumsy form, the swimming-bladder has been developed in an unusually high dorsal position, and, to prevent suffering from a sudden alteration of pressure, has been provided with two strong muscles.

IV. *Report on the Occupation of the Table. By* Mr. ARTHUR WILLEY.

I had been staying at Faro, near Messina, upwards of two months, from the beginning of May, collecting larvæ of *Amphioxus*; and, after having preserved a sufficient quantity up to a certain stage in the development, I had to wait some weeks for the final larval stages. In order to make the best use of my time, I came here on July 15, by the kind permission of the British Association Committee, for the purpose of examining my material and finding out the best method of conservation.

I made preparations *in toto*, and also cut several series of sections with a 'Jung' microtome, and in this way I found that osmic acid was the best reagent for killing the larvæ, as it causes the least amount of histological disturbance. This was obviously a most important point to decide upon for my future preparations.

I have also made use of the library for reading up the literature on the subject, and have paid some attention to the fauna of the Gulf of Naples. I am now returning to Messina. Although I have been at Naples such a short time, less than three weeks, I consider that it has been a great advantage to me to work here, and I am extremely obliged to the Committee of the British Association for permitting me to use their table.

V. *A List of Naturalists who have worked at the Zoological Station from the end of June* 1888 *to the end of June* 1889.

Number on List	Naturalist's Name	State or University whose Table was made use of	Duration of Occupancy	
			Arrival	Departure
453	Dr. S. Pansini . .	Italy . . .	July 1, 1888	Dec. 31, 1888
454	Prof. C. Emery . .	,, . . .	,, 18, ,,	Sept. 28, ,,
455	Prof. de Giaxa . .	,, . . .	Aug. 2, ,,	Oct. 21, ,,
456	Dr. R. Semon . .	Prussia . . .	,, 9, ,,	,, 18, ,,
457	Prof. Ussow . .	Russia . . .	,, 14, ,,	Sept. 10, ,,
458	Stud. Gribowsky .	,, . . .	,, 14, ,,	,, 10, ,,
459	Dr. Jablonowski .	Academy, Berlin .	,, 22, ,,	,, 11, ,,
460	Dr. Benda . .	Prussia . . .	,, 31, ,,	Oct. 18, ,,
461	Dr. D. Baldi . .	Italy . . .	Sept. 13, ,,	Sept. 21, ,,
462	Prof. V. Graber. .	Austria . . .	,, 15, ,,	Oct. 24, ,,
463	Dr. F. Schütt . .	Prussia . . .	,, 16, ,,	Apr. 24, 1889
464	Dr. B. Friedländer .	,, . . .	,, 24, ,,	—
465	Teniente Borja de Goyeneche	Spain . . .	Oct. 1, ,,	Apr. 1, ,,
466	Teniente Shelly y Correa	,, . . .	,, 1, ,,	,, 1, ,,
467	Dr. A. Fritze . .	Baden . . .	,, 1, ,,	Oct. 26, 1888
468	Dr. M. Bedot . .	Switzerland . .	,, 24, ,,	Apr. 22, 1889
469	Prof. G. Vigliarolo .	Italy . . .	Nov. 5, ,,	—
470	Dr. N. A. Cobb . .	British Association .	,, 11, ,,	Jan. 27, ,,
471	Dr. G. C. J. Vosmaer	Holland . . .	,, 14, ,,	,, 10, ,,
472	Dr. B. Lvoff . .	Russia . . .	,, 19, ,,	May 20, ,,
473	Dr. C. Pictet . .	Switzerland . .	Dec. 3, ,,	Apr. 26, ,,
474	Mr. G. Bidder . .	Camb. University .	,, 17, ,,	—
475	Dr. M. de Davidoff .	Zoological Station .	,, 17, ,,	June 19, ,,
476	Mr. F. E. Weiss .	British Association .	,, 30, ,,	May 2, ,,
477	Dr. G. Jatta . .	Italy . . .	Jan. 1, 1889	—
478	Dr. F. Sanfelice .	,, . . .	,, 1, ,,	—
479	Dr. F. Raffaele . .	,, . . .	,, 1, ,,	—
480	Dr. P. Mingazzini .	,, . . .	,, 1, ,,	—
481	Dr. S. Pansini . .	,, . . .	,, 1, ,,	—
482	Dr. G. Arnheim .	Prussia . . .	,, 2, ,,	Apr. 20, ,,
483	Dr. O. Lubarsch .	,, . . .	,, 9, ,,	June 1, ,,
484	Dr. A. Bontyrkine .	Russia . . .	,, 13, ,,	,, 12, ,,
485	Prof. L. Savastano .	Italy . . .	,, 14, ,,	—
486	Mr. W. L. Calderwood	British Association .	,, 20, ,,	May 27, ,,
487	Dr. C. de Bruyne .	Belgium . . .	,, 25, ,,	,, 27, ,,
488	Dr. S. Apáthy . .	Hungary . . .	,, 30, ,,	—
489	Mr. H. Kissling. .	Würtemberg . .	,, 30, ,,	,, 10, ,,
490	Dr. G. Brandes . .	Saxony . . .	Feb. 2, ,,	—
491	Dr. G. Cano . .	Italy . . .	,, 27, ,,	—
492	Dr. J. Wortmann .	Strasburg . .	Mar. 5, ,,	Apr. 21, ,,
493	Dr. H. Ambronn .	Saxony . . .	,, 6, ,,	,, 19, ,,
494	Dr. A. Ostroumoff .	Russia . . .	,, 8, ,,	—
495	Dr. H. Virchow .	Prussia . . .	,, 8, ,,	—
496	Dr. T. Boveri . .	Bavaria . . .	,, 8, ,,	,, 24, ,,
497	Prof. v. Graff . .	Austria . . .	,, 19, ,,	,, 17, ,,
498	Sr. Rioja y Martin .	Spain . . .	Apr. 2, ,,	—
499	Prof. A. Meyer . .	Prussia . . .	,, 4, ,,	,, 24, ,,
500	Prof. F. Vejdowsky .	Austria . . .	,, 6, ,,	,, 22, ,,
501	Dr. F. Quentell . .	Hesse . . .	,, 23, ,,	June 3, ,,
502	Dr. J. M. Janse . .	Holland . . .	,, 26, ,,	—
503	Dr. H. Griesbach .	Prussia . . .	May 5, ,,	,, 26, ,,
504	Dr. W. Wagner .	Russia . . .	June 11, ,,	—
505	Dr. W. Schimkewitsch	,, . . .	,, 11, ,,	,, 26, ,,

VI. *A List of Papers which have been published in the year* 1888 *by the Naturalists who have occupied Tables at the Zoological Station.*

Dr. F. S. Monticelli .	Contribuzioni allo studio della fauna elmintologica del Golfo di Napoli. 'Mitth. Zool. Station, Neapel,' Bd. viii. 1888.
" . .	Intorno allo Scolex polymorphus, Rud. Nota preliminare. 'Boll. Soc. Nat. Napoli,' vol. ii. 1888.
" . .	Saggio di una Morfologia dei Trematodi. Napoli, 1888.
" . .	Osservazioni sul Bothriocephalus microcephalus. Napoli, 1888.
" . .	Sulla Cercaria setifera, Müll. 'Boll. Soc. Nat. Napoli,' vol. ii. 1888.
Dr. N. Kastschenko .	Zur Frage über die Herkunft der Dotterkerne im Selachierei. 'Anat. Anz.' 1888.
" . .	Zur Entwickelungsgeschichte des Selachierembryos. 'Anat. Anz.' 1888.
Dr. R. Semon . .	Die Entwickelung der Synapta digitata, etc. 'Jen. Zeitschr. f. Naturw.' Bd. xxii. N. F. 15, 1888.
Dr. A. Fleischmann .	Die Entwickelung des Eies von Echinocardium cordatum. 'Zeitschr. wiss. Zoologie,' Bd. xlvi. 2, 1888.
Dr. F. Sanfelice . .	Spermatogenesi dei Vertebrati. 'Boll. Soc. Nat. Napoli,' vol. ii. 1888.
" . .	Intorno alla Rigenerazione del Testicolo. *Ibid.*
Mr. H. Bury . . .	The Early Stages in the Development of Antedon rosacea. 'Proc. Royal Soc.' vol. xliii. 1888 (abstract).
" . . .	The Early Stages in the Development of Antedon rosacea. 'Phil. Trans. Royal Soc.' London, vol. clxxix. 1888.
Prof. A. Mosso . .	Il sangue nello stato embrionale e la mancanza di leucociti. 'Rendiconti R. Accademia dei Lincei, Roma,' vol. iv. fasc. 8, 1888.
" . .	Il Veleno dei Pesci e delle Vipere. 'Nuova Antologia,' ser. iii. vol. xvi. 1888.
Dr. B. Rawitz . .	Der Mantelrand der Acephalen. I. Theil, Ostracea. 'Jen. Zeitschr. f. Naturw.' Bd. xxii. 1888.
Dr. M. Joseph . .	Zur feineren Structur der Nervenfaser. 'Arch. Anat. Physiol.' Phys. Abth. 1888.
" . .	Die vitale Methylenblau-Nervenfärbungs-Methode bei Heteropoden. 'Anat. Anz.' Bd. iii. 1888.
" . .	Ueber einige Bestandtheile der peripheren markhaltigen Nervenfaser. 'Sitz.-Ber. Kön. Pr. Akad. der Wiss. Berlin,' 1888
Dr. P. Pelseneer . .	Sur la valeur morphologique des bras et la composition du système nerveux central des Céphalopodes. 'Arch. Biol.' tome viii. 1888.
Dr. J. Rückert . .	Ueber die Entstehung der Excretionsorgane bei Selachiern. 'Arch. Anat. Physiol.' Anat. Abth. 1888.
" . .	Ueber die Entstehung der endothelialen Anlagen des Herzens u. der ersten Gefässstämme bei Selachier-Embryonen. 'Biol. Centralblatt,' 1888.
Dr. S. v. Apáthy . .	Analyse der äusseren Körperform der Hirudineen. 'Mitth. Zool. Station, Neapel,' Bd. viii. 1888.
" . .	Süsswasser-Hirudineen. Ein systematischer Essay. 'Zool. Jahrbücher,' Bd. iii. 1888.
" . .	Systematische Streiflichter. I. Marine Hirudineen. 'Archiv f. Naturgesch.' 54. Jgg. Bd. i. 1888.
Dr. T. Boveri . . .	Ueber partielle Befruchtung. 'Sitz.-Ber. Ges. Morphol. Physiol.' München, 1888.
Prof. A. Della Valle .	Sopra le Glandole Glutinifere o sopra gli Occhi degli Ampeliscidi del Golfo di Napoli. 'Atti della Soc. dei Natural. di Modena,' ser. iii. vol. vii. 1888.

Dr. P. Mingazzini . .	Ricerche anatomiche ed istologiche sul tubo digerente delle larve di alcuni Lamellicorni fitofagi. 'Boll. Soc. Nat. Napoli,' vol. ii. 1888.
Dr. F. Raffaele . .	Le uova galleggianti e le larve dei Teleostei nel Golfo di Napoli. 'Mitth. Zool. Station, Neapel,' Bd. viii. 1888.
" . .	Osservazioni sopra l'Orthagoriscus mola. 'Boll. Soc. Nat. Napoli,' vol. ii. 1888.
Dr. G. Kalide . . .	Vorläufige Mittheilung über Studien am Gastropoden- u. am Pectenauge. 'Zool. Anz.' 1888.
Dr. F. Noll . . .	Die Farbstoffe der Chromatophoren von Bangia fusco-purpurea.' 'Arbeiten a. d. bot. Institut in Würzburg,' Bd. iii. 1888.
" . . .	Ueber die Function der Zellstofffasern der Caulerpa prolifera. *Ibid.*
" . . .	Ueber den Einfluss der Lage auf die morphologische Ausbildung einiger Siphoneen. *Ibid.*
Dr. F. A. F. C. Went .	Verslag omtrent de onderzoekingen verricht aan de Nederlandsche Tafel in het Zool. Station te Napels. 1888.
Dr. J. van Rees . .	De beteekenis der Chorocyten voor den graad der voeding van snel groeiende weefsels. Nederland. Tydschrift voor Geneeskunde. 'Feestbundel Donders-Jubiléum,' 1888.
Dr. E. de Daday . .	System. Uebersicht der Dinoflagellaten des Golfs von Neapel. 'Termeszetrajzi Füzetek,' vol. xi. 1888.
" . .	Eine freischwimmende Acinete aus dem Golfe von Neapel. *Ibid.*

VII. *A List of Naturalists, &c., to whom Specimens have been sent from the end of June* 1888 *to the end of June* 1889.

					Lire c.
1888.	July	3	Laboratoire d'Anatomie Comp., Geneva	Ascidia . . .	13·70
	"	11	Liceo Virgilio, Mantua . .	Collection . . .	92·65
	"	12	Mr. G. Brook, Edinburgh . .	Antipathes . . .	26·40
	"	13	Bing fils et Gans, Paris . .	Various . . .	98·20
	"	"	Dr. Stachow, Bremen . .	Various . . .	34·25
	"	25	University of Wisconsin, Madison	Collection . . .	1439·50
	"	15	Faculté des Sciences, Nancy .	Collection . . .	395·40
	"	16	School of Physic, Dublin . .	Various . . .	36·75
	"	"	Laboratoire d'Anatomie Comp., Geneva	Salpa	13·80
	"	20	Bryn Mawr College . . .	Various . . .	153·75
	"	18	Cab. d'Anat. Comp., Moscow .	Collection . . .	277·65
	"	19	Zool. Museum, Copenhagen .	Various . . .	54·50
	"	24	'Linnæa,' Berlin . . .	Collection . . .	337·60
	"	25	Zool. Institut, Marburg . .	Various . . .	71·50
	"	26	Zool. Institut, Göttingen . .	Natica	3·35
	"	"	Prof. Klug, Klausenburg . .	Mollusca . . .	10·
	"	27	University College, London .	Amphioxus . . .	7·10
	"	"	Prof. Weismann, Freiburg .	Pedicellina . . .	2·05
	"	28	Mme. Vimont, Paris . . .	Torpedo . . .	10·50
	Aug.	2	Mr. E. Burdet, Morges . .	Various . . .	35·65
	"	27	University College, London .	Scorpions . . .	107·40
	"	"	Gal Frères, Nice . . .	Various . . .	19·75
	"	"	Mr. Gardeau de Kerville, Rouen	Chætopterus . .	8·70
	"	"	Dr. G. Kohl, Marburg . .	Lithothamnion . .	13·25
	"	"	Mr. Stroell, Amberg . . .	Corallium . . .	12·35
	"	28	Haverford College, Pa. . .	Various . . .	96·65
	"	31	University College, London .	Aplysia . . .	144·10
	"	"	Williams College, Williamstown	Arthropods . . .	163·50

					Lire c.
1888.	Sept.	8	Prof. Vitzou, Univ. Bucarest	Collection	828·25
	,,	8	Prof. Ussow, Zool. Inst., Kasan	Collection	322·90
	,,	10	Anatom. Institute, Leipzig	Embryos of Selachians	51·05
	,,	12	'Linnæa,' Berlin	Corallium	20·25
	,,	17	Zoolog. Genotschap, Amsterdam	Collection	300·
	,,	,,	Municipality, Berlin	Collection	482·50
	,,	20	Mr. Gadeau de Kerville, Rouen	Pelagia	10·15
	,,	28	Prof. Hatschek, Prague	Collection	1094·35
	,,	,,	Zootom. Institute, Dublany	Various	110·
	Oct.	10	Ateneo Galileo Galilei, Naples	Collection	100·
	,,	,,	Dr. F. Keibel, Strasburg	Embryos of Selachians	20·90
	,,	,,	Dr. J. Beard, Freiburg	Embryos of Selachians	47·55
	,,	19	Zootom. Museum, Christiania	Amphioxus	2·20
	,,	20	Mme. Vimont, Paris	Eggs of Octopus, &c.	37·45
	,,	22	Dr. Edinger, Frankfurt a/M.	Brains of Selachians	25·50
	,,	27	Instit. d'Anat. Comp., Naples	Collection	431·94
	,,	24	Musée Royal, Brussels	Fish	446·35
	,,	20	Rijks Museum, Leyden	Arenicola	5·85
	,,	25	Dr. Detlefsen, Wismar	Caulerpa	5·70
	,,	,,	Mr. H. C. Chadwick, Manchester	Agalma	24·75
	,,	31	Prof. de Famintzin, St. Petersburg	Algæ	46·30
	,,	,,	Prof. Arndt, Greifswald	Amphioxus	11·15
	Nov.	5	Zool. Inst., Munich	Various	27·05
	,,	,,	Mme. Vimont, Paris	Various	184·80
	,,	,,	Prof. Reinke, Kiel	Algæ	3·10
	,,	,,	Prof. Hansen, Copenhagen	Larvæ of Squilla	—
	,,	7	Dr. B. Rawitz, Berlin	Mollusca	10·55
	,,	9	Dr. C. Hartlaub, Bremen	Various	9·10
	,,	13	Prof. G. Vimercati, Florence	Various	44·65
	,,	16	Zool. Inst., Czernowitz	Collection	253·70
	,,	15	Queen's College, Galway	Collection	402·25
	,,	14	Mr. B. M. Gunn, London	Charybdæa	8·75
	,,	16	Dr. Peracea, Turin	Lacerta	12·50
	,,	20	Museo Zoologico, Naples	Collection	227·45
	,,	,,	Veterinär-Institut, Dorpat	Collection	145·80
	,,	23	Zoolog. Museum, Upsala	Collection	202·70
	,,	24	Dr. Kükenthal, Jena	Vermes	12·35
	,,	27	Museo Zoologico, Modena	Mollusca	121·25
	,,	,,	Prof. Pantanelli, Modena	Various	7·90
	,,	,,	Prof. A. Mosso, Turin	Scyllium (blood)	4·15
	,,	,,	Mr. Doebeli, Aarau	Living specimens	6·60
	Dec.	3	Mr. G. Krause, Glogau	Various	27·20
	,,	,,	Mr. E. Schulz, Glogau	Various	14·50
	,,	,,	Mr. Dáll' Eco, Florence	Various	8·50
	,,	7	Labor. de Zoologie, Nancy	Various	11·70
	,,	10	Mme. Vimont, Paris	Collection	112·70
	,,	,,	Zool. Museum, Charkoff	Siphonophora	100·
	,,	15	Miss Schaepman, Leyden	Collection	161·15
	,,	14	Istituto Zoologico, Perugia	Various	23·55
	,,	15	Museo Zoologico, Pisa	Spatangus	11·25
	,,	12	Dr. E. Pergens, Maeseyck	Bryozoa	5·40
	,,	20	Rev. Dr. Norman, Burnmoor Rectory	Collection	355·90
	,,	21	Accademia dei Fisiocritici, Siena	Collection	118·10
	,,	28	Presidency College, Madras	Collection	279·90
	,,	20	Morphological Laboratory, Cambridge	Carmarina, Amphioxus	74·90
	,,	19	Zoolog. Institute (Prof. Chun), Königsberg	Siphonophora	—
1889.	Jan.	3	Anatom. Inst., Bonn	Loligo	2·80
	,,	7	Scuola di Agricoltura, Milan	Various	73·35
	,,	5	Dr. L. Eger, Vienna	Various	50·20

					Lire c.
1889.	Jan.	6	Prof. A. Mosso, Turin	Pristiurus (blood)	5·20
	,,	8	University, Melbourne	Collection	908·75
	,,	7	Prof. Hubrecht, Utrecht	Amphioxus	10·65
	,,	12	Zool. Inst., Munich	Amphioxus	5·10
	,,	,,	Inst. of Technology, Boston	Collection	480·55
	,,	16	Mr. G. Krause, Glogau	Various	30·
	,,	19	Zool. Sammlung, Berlin	Collection	1357·45
	,,	21	Dr. B. Strubell, Frankfurt a/M.	Mollusca	21·90
	,,	19	Mr. Alfred Heath, London	Murex, Pagellus	9·55
	,,	20	Dr. F. Keibel, Strasburg	Embryos of Pristiurus	17·90
	,,	24	Mr. A. Kreidl, Prague	Collection	286·10
	,,	,,	Mr. F. Bernard, Paris	Mollusca	17·95
	,,	26	Dr. Peracca, Turin	Lacerta	12·50
	,,	,,	Thomas-Gymnasium, Leipzig	Collection	80·60
	,,	27	Gabin. d'Anatom. Compar., Rome	Various	42·25
	,,	28	Morphological Laboratory, Cambridge	Dromia, Callianassa	23·65
	,,	,,	Mr. W. Garstang, Plymouth	Perophora Listeri	3·
	,,	31	Istituto Zoologico, Genoa	Collection	322·60
	,,	,,	Académie, Lausanne	Echinodermata	37·50
	,,	,,	Prof. D. Carazzi, Spezia	Various	12·90
	,,	,,	Anatom. Inst., Würzburg	Electric organs of Torpedo	2·90
	,,	,,	Dr. Verworn, Jena	Algæ	5·95
	Feb.	4	Dr. B. Rawitz, Berlin	Mollusca, Embryos of dogfish	42·65
	,,	7	Prof. Claus, Zool. Inst., Vienna.	Collection	168·60
	,,	9	Geol. Inst., Freiburg	Cephalopoda	70·75
	,,	7	Prof. Mosso, Turin	Scyllium (blood)	8·05
	,,	8	Dr. W. Müller, Greifswald	Ostracoda	5·
	,,	,,	André et Lieutier, Marseilles	Various	21·20
	,,	19	Comp. Anatomy Museum, Lahore	Collection	608·80
	,,	,,	Zool. Inst., Vienna	Various	8·30
	,,	20	Zool. Inst., Göttingen	Various	13·45
	,,	21	Baron de S. Joseph, Paris	Annelida	15·90
	,,	22	Prof. Joyeux-Laffuie, Luc-sur-Mer	Chætopterus	11·15
	,,	27	Zool. Instit., Berlin	Collection	1089·
	March	2	Zool. Instit., Leipzig	Embryos of Torpedo	22·20
	,,	,,	University, Edinburgh	Embryos of Torpedo	16·15
	,,	,,	Municipality, Berlin	Collections	401·
	,,	,,	Zool. Instit., Leyden	Collections	220·85
	,,	3	Dr. Jickeli, Hermannstadt	Echinodermata	15·15
	,,	,,	Anatom. Instit., Munich	Embryos of Pristiurus	26·40
	,,	5	Museo Zoologico, Perugia	Phoronis	3·60
	,,	6	Gal Frères, Nice	Various	40·85
	,,	,,	Museo Zoologico, Naples	Cephalopoda	15·55
	,,	9	Mr. J. Tait, Leith	Amphioxus	4·60
	,,	,,	Dr. P. Pelseneer, Ghent	Solenomya	2·80
	,,	11	Kathedralskole, Aalborg	Various	34·20
	,,	,,	Dr. Hagen, Nürnberg	Various	24·75
	,,	15	Dr. A. Appellöf, Upsala	Sepia	17·05
	,,	16	Musée d'Hist. Nat., Douai	Collection	603·70
	,,	19	Andrée et Lieutieur, Marseilles	Tunicata	11·25
	,,	23	Dr. Bousfield, London	Chiton	6·30
	,,	30	Ministerio de Marina, Madrid	Collection	500·
	April	10	Mme. Vimont, Paris	Torpedo, Petromyzon	18·35
	,,	,,	Anatom. Inst., Bonn	Scyllium, Raja	10·
	,,	12	'Linnæa.' Berlin	Collection	270·
	,,	,,	Calderoni & Co., Budapest	Collection	996·30
	,,	15	Museo Zoologico, Siena	Collection	246·70
	,,	17	Gymnasium, Constanz	Pennatula	8·

				Lire c.
1889. April	17	Prof. Whitman, Milwaukee	Various	—
,,	27	Brunnschweiler & Sohn, S. Gall	Sepia (colouring matter)	46·45
,,	,,	Mr. G. Schneider, Basel	Siphonophora	51·30
May	4	University, Warsaw	Various	180·65
,,	,,	Zool. Inst., Giessen	Various	136·25
,,	5	Anatom. Instit., Munich	Embryos, Pristiurus	24·95
,,	,,	Dr. B. Rawitz, Berlin	Embryos, Pristiurus	22·30
,,	8	Mr. I. Tempère, Paris	Various	137·65
,,	10	Zoolog. Instit., Leyden	Various	100·
,,	,,	Gymnasium, Mülheim a/R.	Collection	64·85
,,	8	Mme. Vimont, Paris	Various	61·05
,,	12	Zoolog. Inst., Tübingen	Siphonophora	175·75
,,	,,	Prof. d'Oliveira, Coimbra	Crustacea	10·05
,,	23	Dr. P. Canusi, Naples	Various	16·45
,,	,,	Zoolog. Inst., Jena	Various	14·45
,,	,,	Zoolog. Inst., Odessa	Distaplia	5·85
,,	,,	Prof. C. Grobben, Vienna	Astarte	1·80
,,	25	Mr. W. Karavaieff, Kiew	Siphonophora	20·
,,	26	University, Edinburgh	Amphioxus	9·95
,,	28	Zoolog. Instit., Bonn	Collection	232·25
June	1	Pathol. Instit., Zurich	Various	31·35
,,	,,	Zoolog. Instit., Munich	Oceania, Sphærozoum	14·75
,,	7	Realschule, Eisenach	Collection	125·
,,	8	Mr. H. Sontag, Wolgast	Collection	75·
,,	12	Zoolog. Inst., Munich	Dogfish	44·40
,,	,,	Zoolog. Inst., Leyden	Mollusca	13·05
,,	,,	Realschule, Gr. Umstadt	Collection	125·
,,	,,	Mädchenschule, Worms	Collection	125·
,,	,,	Volksschule, Worms	Collection	110·25
,,	17	Scuola Superiore Femminile, Florence	Collection	164·55
,,	24	Mr. E. W. Serpell, Plymouth	Collection	395·70
,,	,,	Dr. R. Schneider, Berlin	Mollusca	28·65
,,	,,	School of Physic, Dublin	Amphioxus	10·90
,,	,,	Sig. G. Schlatter, Catania	Various	10·75
,,	,,	Mr. A. de Firsoff, Karlsruhe	Various	21·50
,,	25	Faculté des Sciences, Montpellier	Various	49·50
,,	30	Zoolog. Museum, University, Tomsk (Siberia)	Collection	1000·
				24151·74

Report of the Committee, consisting of Professors E. A. Schäfer *and* W. A. Herdman *and* Mr. W. E. Hoyle (*Secretary*), *appointed to improve and experiment with a Deep-sea Tow-net, for opening and closing under water.*

The following report has been drawn up by Mr. Hoyle and Professor Herdman, by whom the work of the Committee has been jointly carried out:

Since the last meeting of the Association we have modified and improved the piece of apparatus (known as the 'lock') by which the two rods attached to the net are successively let go. The new lock avoids certain possibilities of failure, which were present in the provisional one first constructed.

A full description of it, with figures, has been drawn up and published in the 'Proceedings of the Liverpool Biological Society,' vol. iii.

On April 18 the apparatus was taken on board the salvage steamer 'Hyæna,' on one of the expeditions of the Liverpool Marine Biology Committee, but the weather was so unfavourable that no experiments could be attempted.

After several unsuccessful attempts to arrange another cruise, the use of the steam tug 'Spindrift' was procured from the Liverpool Steam Tug Co., and on July 20 an expedition set out from Holyhead for the purpose of conducting the experiments. Several hauls were taken with the net, and the materials obtained were placed in the hands of Mr. I. C. Thompson, F.L.S., the results of whose investigation will appear in the 'Proceedings of the Liverpool Biological Society.' The apparatus worked without a hitch, save once, when a small piece of rope which was floating in the water became twisted round the line and thus prevented the descent of the messengers.

The possibility of such an occurrence had always been foreseen, but, in our opinion, it is not sufficiently serious to militate against the use of the apparatus in shallow water. The operation does not take long, and if one haul should fail it is easy to make another.

In the exploration of great depths, to which it is hoped this tow-net may shortly be applied, the case is different. The period occupied in letting out and hauling in the line, taken in conjunction with the time required for dragging the net, is so great that it becomes imperative to remove every possible risk of losing an observation. Furthermore, the time occupied by the messengers themselves in descending the line is a not unimportant factor in the case.

We were so much impressed by these considerations, that it was resolved to attempt the construction of a lock which should bring about the opening and closing of the net by means of an electric current, transmitted along wires passing down the interior of the line by which the net is drawn. This plan has so far succeeded that a provisional model has been constructed, which will be exhibited to the present meeting of the Association. The lock contains an electro-magnet, the armature of which actuates an escapement which, the first time contact is made, liberates the opening rod, and the second time the closing rod of the net. Such an arrangement is obviously instantaneous in its action, and not liable to interference from external causes.

In conclusion, we desire to express our indebtedness to Messrs. B. & S. Massey, who have constructed the apparatus for us.

Third Report of the Committee, consisting of Mr. THISELTON-DYER (*Secretary*), Mr. CARRUTHERS, Mr. BALL, Professor OLIVER, *and* Mr. FORBES, *appointed for the purpose of continuing the preparation of a Report on our present knowledge of the Flora of China.*

SINCE the last meeting of the British Association two additional parts of the *Index Floræ Sinensis* have been published, bringing the enumeration of known and the description of new species as far as the *Loganiaceæ*. The Committee now, therefore, look forward with some confidence to the completion of their labours at no distant date.

Further extensive and valuable collections have been received from

China in aid of the work, more especially from Dr. Augustine Henry, late of Ichang. The novelty and richness of the material obtained by this indefatigable botanist far exceeds any expectations the Committee could have formed. It is to be regretted that his duties as an officer of the Chinese Imperial Maritime Customs have necessitated his removal to Hainan. It is probable, however, that he had practically exhausted the immediate neighbourhood of Ichang, and that without opportunities of travelling over a wider radius, which the Committee regret they were unable to procure for him, he would not have been able to add much of material novelty to the large collections already transmitted by him to Kew.

The Committee have met with the kindest sympathy and assistance in their labours from Dr. C. J. de Maximowicz of the Académie Impériale of St. Petersburg, who has long been engaged on the elaboration of the collections made by Russian travellers in China, and from M. Franchet of the Muséum d'Histoire Naturelle at Paris, who is describing and publishing the extremely rich collections made by the French missionaries in Yunnan.

The Committee have received striking proofs of the appreciation of their labours by botanists of all countries. They permit themselves to quote the following passage from a letter received early in the present year from Baron Richthofen, than whom no one is more competent to estimate the value of work connected with the scientific exploration of China:—

'It is of great value to have, now, a Flora of China, embodying all the species known from that country. You have evidently succeeded at Kew in getting a very complete collection. At the same time, in looking over the localities mentioned in the book, it strikes me that large portions of China are still unexplored botanically. There remains a splendid field for a good collector in the Tsingling Mountains, the province of Sz'chuen, and chiefly its elevated regions west of Ching-tu-fu. Work in those parts will be greatly facilitated by the solid foundation laid through the work of Forbes and Hemsley.'

The Committee derive an independent existence as a Sub-Committee of the Government Grant Committee of the Royal Society. They are at present in possession of sufficient funds to enable them to carry on the work. They do not therefore ask for their reappointment at the hands of the British Association.

Report of the Committee, consisting of Professor A. Newton (*Chairman*), Mr. W. T. Thiselton-Dyer, Professor M. Foster, *and* Mr. S. F. Harmer (*Secretary*), *appointed for the purpose of taking steps for the investigation of the Natural History of the Friendly Islands, or other Groups in the Pacific, visited by H.M.S. 'Egeria.'*

The Committee have not yet received information which puts them in a position to give any detailed report of the work which is being done in connection with the above subject. The grant has been paid to Mr. J. J. Lister, who reached Tonga on March 19. After devoting two months to the investigation of the natural history of that group, Mr. Lister joined H.M.S. *Egeria*, on her arrival at Tonga, with the intention of visiting Samoa, where, by the latest accounts, he was carrying on his researches.

Report of the Committee, consisting of Professor NEWTON, Mr. JOHN CORDEAUX (*Secretary*), Mr. J. A. HARVIE-BROWN, Mr. R. M. BARRINGTON, Mr. W. E. CLARKE, *and the* Rev. E. P. KNUBLEY, *appointed to make a digest of the observations on Migration of Birds at Lighthouses and Lightvessels which have been carried on during the past nine years by the Migrations Committee of the British Association (with the consent of the Master and Elder Brethren of the Trinity House and the Commissioners of Northern and Irish Lights), and to report upon the same.*

YOUR Committee have to report that one of their number, Mr. W. Eagle Clarke, of the Museum of Science and Art at Edinburgh, has, with the approbation of your Committee, undertaken to prepare the digest of the observations; and all the materials for making the same, including 1,500 skeleton maps of the British Islands, provided for the purpose, have accordingly been placed in his hands. The labour of reducing the observations, to show in a concise form and on strictly scientific lines the results of the investigation which was carried on from 1879 to 1887 inclusive, will be easily understood to be enormous; and when it is borne in mind that this heavy work can only be carried on after official hours, your Committee feel that no apology is necessary for the non-completion of the digest this year. They would respectfully solicit their reappointment with the same object as before.

Third Report of the Committee, consisting of Professor FOSTER, Professor BAYLEY BALFOUR, Mr. THISELTON-DYER, Dr. TRIMEN, Professor MARSHALL WARD, Mr. CARRUTHERS, Professor HARTOG, *and* Professor BOWER (*Secretary*), *appointed for the purpose of taking steps for the establishment of a Botanical Station at Peradeniya, Ceylon.*

THE Secretary of the above Committee reports that Mr. Potter, of St. Peter's College, Cambridge, has, during the past year, spent about four months at Peradeniya, for purposes of collection and research, and that he has brought back with him a large number of specimens, together with materials for researches on abnormal stems, and other subjects, the results of which will be published as soon as time permits. Before he started, steps were taken to provide him from the grant of 50*l.* (which was drawn in 1888) with such apparatus as would be useful to him, and at the same time would remain permanently in the laboratory for the use of those who may follow him. This apparatus, which covers the ordinary requirements of a working botanist, has been left by him in good order. A suitable room having been set apart by Dr. Trimen in the Botanic Garden, part of the grant was expended in furnishing it, and the furniture remains in the laboratory. Thus the Committee has been able, by an expenditure which is within the limits of the grant, to equip a small room in such a way as to meet the first needs of botanical students. There is much, however, that should be added, both in reagents and apparatus; while a proper water supply and sink are also urgently required. Therefore the Committee, while requesting that they may be reappointed for the ensuing year, ask also for a further grant of 50*l.*

Seventeenth Report of the Committee, consisting of Professors J. PRESTWICH, W. BOYD DAWKINS, T. McK. HUGHES, *and* T. G. BONNEY, Dr. H. W. CROSSKEY, *and* Messrs. C. E. DE RANCE, W. PENGELLY, J. PLANT, *and* R. H. TIDDEMAN, *appointed for the purpose of recording the Position, Height above the Sea, Lithological Characters, Size, and Origin of the Erratic Blocks of England, Wales, and Ireland, reporting other matters of interest connected with the same, and taking measures for their preservation.* (*Drawn up by* Dr. CROSSKEY, *Secretary.*)

IT is still too soon to summarise the reports which this Committee has presented, since new facts are constantly being brought to light. It would be of great service if a committee like the 'Yorkshire Boulder Committee' were formed in every county; were that done, the record of English erratics could soon be made complete, to the great advantage of the students of glacial geology.

The Yorkshire Committee carefully examines the reports presented to it by individual observers, and collects typical rocks to aid them in the determination of the specimens sent.

The valuable map of the distribution of erratics in the Midlands, by Mr. Fred. W. Martin, F.G.S., which was exhibited in an unfinished state at the Birmingham meeting of the Association, is approaching completion. It is strongly recommended that similar maps should be prepared in other districts, erratics of different types being recorded in various colours. Only by mapping will the remarkable facts connected with their distribution be brought clearly out.

The investigations of each year give fresh emphasis to the important points which were noted in last year's report as being gradually brought to light, viz.:

(1) The grouping of erratics from distinct regions in distinct localities, erratics from a special district being often found without the intermixture of others.

(2) The occasional intermixture of groups of erratics from different localities, this intermixture being connected with the physical features of the district, *i.e.*, with the paths open for the ice to take, whether it descended as a glacier from the higher hills, or floated in the shape of icebergs over the submerged land.

(3) The occurrence of erratics at such different levels as to necessitate different explanations of the method by which they were distributed, the high-level erratics demanding special consideration.

(4) The distribution of trails and groups of low-level erratics in accordance with the present arrangements of mountains, valleys, and plains, so that their 'flow' may be traced from their distant sources along natural passages.

It is not the duty of the Committee to submit any theories, but simply to record the facts which have to be explained. What these facts are, however, will become more apparent when a summary of these reports is prepared.

YORKSHIRE.

From the Yorkshire Boulder Committee the subjoined series of valuable reports has been received; Prof. L. C. Miall, F.L.S., having acted as its chairman, and Mr. S. A. Adamson, F.G.S., as its secretary. Mr. Samuel

Chadwick, F.G.S. (Hon. Curator of the Malton Museum), reports the following erratics:—

Strensall, near York.—(1) In the village of Strensall, on the east side of the main road, and forming the corner-stone of a road leading into the farm of Mr. Hodgson, is a boulder. It is 3 ft. 3 in. × 2 ft. 1 in. × 1 ft. 8 in., rounded and oblong; has been moved; no striæ or groovings; coarse gritty, Carboniferous sandstone; about 100 ft. above sea-level; rests upon sand and clay.

(2) In the village of Strensall are about twenty scattered boulders, varying from 1 ft. 8 in. × 1 ft. × 11 in. to 1 ft. × 9 in. × 8 in.; subangular to rounded; they are generally isolated; they are chiefly sandstones and whinstones, and upon some of the latter are distinct grooves, 5 in. to 6 in. long, in the direction of their longest axes; about 100 ft. above sea-level.

Note.—Below the surface soil in this district there is a great depth of boulder clay, which for the last 100 years or more has been worked for the purpose of marling the land, and during the excavation the boulders met with were carefully preserved, some for road metal, the larger and harder ones for corner-stones, mounting-blocks, cheese-presses, &c. The clay deposit varies considerably; although that of a dark-blue nature predominates, yet there are beds of sand and light red clay in other places.

Flaxton.—(3) Near the signpost in the centre of the village of Flaxton is a boulder. It is 3 ft. × 2 ft. 6 in. × 1 ft. 9 in.; subangular; has been moved; no striæ or groovings; mountain limestone; about 120 ft. above sea-level.

Note.—This stone formerly marked the boundary between the parishes of Foston and Bossall, and was called the 'Rambleations Stone,' this being a local word signifying an assemblage of people. A dole of bread was at stated periods distributed, but, it is said, to avoid jealousy or favouritism, it was thrown from this stone amongst the crowd, leading often to free fights. This custom is discontinued, money being now distributed, and the stone removed.

(4) In the village of Flaxton, about a mile S.E. of the railway-station, on Mr. G. Lobley's estate, is a boulder 4 ft. 8 in. × 2 ft. 4 in. × 1 ft. 6 in.; subangular; no striæ or groovings; mountain limestone; has been moved from adjoining land; about 120 ft. above sea-level; rests on sand and clay.

Note.—This stone has also been used as a boundary-stone between the parishes of Foston and Bossall.

(5) At the north end of the village of Flaxton, in a small grass-field, and not far from a pond, also about half a mile S.E. of the railway-station, is a boulder. It is 4 ft. × 3 ft., but is being covered up, as it hinders vegetation; subangular; has not been moved; longest axis E. and W., but could not discern any striæ; about 150 ft. above sea-level; rests on sand and clay; mountain limestone.

Note.—There are several smaller boulders about the village, but they are being broken up for road metal.

Burniston, near Scarbro'.—(6) In the parish of Burniston, near Scarborough, on the estate of Lord Londesborough, and on the N.E. side of the Burniston and Scalby road, about half-way betwixt the two villages, is a Shap Fell boulder; 3 ft. 6 in. × 2 ft. 10 in. × 2 ft. above ground; rounded; was brought from the field adjoining (tenant, Mr. D. Cockerill) to its present position; no groovings or striæ; rests upon boulder clay.

NOTE.—The district of Burniston and Scalby is undulating in character, and is overlaid by boulder clay and gravel.

Seamer, near Scarbro'.—(7) On East Field Farm, occupied by Mr. Taylor (parish of Seamer, estate of Lord Londesborough), a little east of Seamer station, there are six boulders in a field close to the house.

They vary in size from 2 ft. 7 in. × 1 ft. 8 in. × 1 ft. 2 in. to 1 ft. 6 in. × 10 in. × 8 in.; three of them are hard blue whinstone, one a fine hard sandstone, and the two remaining ones a rough-grained soft sandstone; are about 120 ft. above sea-level; they have recently been brought from adjoining fields, and show no striæ or groovings.

Muston, near Filey.—(8) On Mount Pleasant Farm (estate of Darley's trustees), in the parish of Muston, and about $1\frac{1}{2}$ miles W. of Filey, are twelve boulders, varying in diameter from 2 ft. to 9 in.; rounded to subangular; they have been collected from the adjacent land, and brought as foundations for buildings &c.; three of these are hard sandstone, the remainder granite and whinstone.

(9) In Mr. Atkinson's garden, at the north end of the village of Muston, is a boulder 1 ft. 5 in. × 1 ft. 7 in. × 1 ft. 5 in. out of ground; subangular; no striæ or groovings; whinstone; 150 ft. above sea-level; rests on gravel.

(10) At the north end of the village of Muston, upon an open space of grass at the junction of the roads leading to Malton, Filey, and Bridlington, are about 20 boulders, varying in size from 2 ft. 4 in. × 1 ft. to 1 ft. × 1 ft.; generally subangular; whinstone and sandstones; no striæ or groovings observed; have been collected from adjacent land.

(11) At the south end of the village of Muston, at the corner of the house occupied by Mr. Nellist, is a boulder 1 ft. 10 in. × 1 ft. 10 in. × 1 ft. 5 in.; subangular; whinstone; about 150 ft. above sea-level; no striæ or groovings observed.

(12) Near the cross-roads in Muston village is a footpath the boundary stones of which are boulders, varying from 2 ft. × 1 ft. 6 in. to 1 ft. 2 in. × 1 ft.; rounded and subangular; whinstone, granite and sandstone; no striæ or groovings exposed; they have been thus placed beyond the memory of the 'oldest inhabitant,' but have been brought, without doubt, like the others, from the adjacent land.

(13) On Mr. Nellist's farm, at the south end of Muston village, is a boulder 4 ft. 4 in. × 1 ft. 9 in. × 2 ft. 2 in. out of ground; subangular; is long-shaped, and the direction of its longest axis was (until recently moved) N. and S.; striæ can be seen; about 150 ft. above sea-level; whinstone.

(14) At the north end of Muston village, at the corner of Mr. Chapman's house, is a boulder 1 ft. 8 in. × 1 ft. 8 in. × 1 ft. 3 in. above ground; rounded; has been moved; no striæ; granite.

(15) In the centre of Muston village is a plot of ground which has been levelled and planted with trees, and upon it are from 20 to 30 boulders, varying from 4 ft. 6 in. × 2 ft. to 2 ft. × 1 ft. 6 in.; no striæ or groovings observed; sandstone, whinstone, limestone, and granite.

NOTE.—The district around Muston is composed of long ridges of gravel, sand, and clay running north and south.

York.—(16) In making a siding for the York Gas Company, Foss Islands, York (parish of St. Cuthbert), a boulder was taken out at a depth of 15 ft. below the surface; 2 ft. 5 in. × 2 ft. 4 in. × 1 ft. 11 in.; subangular; no striæ can be seen; mountain limestone with producti;

the excavation would be about the level of the river. It is now at the east end of the Malton goods-station.

Whitby.—(17) On the shore in front of the West Cliff Saloon, Whitby, is a boulder 4 ft. 4 in. × 3 ft. 4 in. × 2 ft. 2 in.; subangular; no striæ or groovings; mountain limestone with fine sections of coral. This boulder has doubtless fallen from the adjacent boulder clay which overlies the estuarine deposits, the latter forming here the base of the cliff. It is covered over at high water.

Foston-le-Clay.—(18) On the roadside, at the east end of Foston churchyard (estate of Sir E. Lechmere), is a boulder. It is 3 ft. 9 in. × 3 ft. 4 in. × 1 ft. 9 in. out of the ground; angular, and almost square at its longest axis; no striæ or groovings, the block having been partially destroyed; limestone; about 200 ft. above sea-level; is nearly at the top of a long ridge of boulder clay running nearly N. and S.

(19) At the east end of a house occupied by Mrs. Ettie, in the village of Foston, is a boulder. It is 2 ft. 10 in. × 1 ft. 3 in. × 2 ft. out of the ground; angular; has been moved; no striæ or groovings; grey granite; about 150 ft. above sea-level; on the same ridge as No. 18.

(20) On Mr. Barker's farm in the village of Foston is a boulder. It is 2 ft. 6 in. × 2 ft. 6 in. × 2 ft. out of ground; rounded; no striæ or groovings; Shap Fell granite; about 150 ft. above sea-level; on the same ridge as No. 18.

(21) On the same farm has been constructed a raised footpath round the fold yard, and entirely composed of boulders. Probably 100 of these (flanking the path) are 1 ft. × 8 in., and 1,000 from 6 in. to 8 in. in diameter. They are rounded to subangular, and a few show striæ in the direction of their longest axis. They are sandstones, limestones, granites and whinstones. This farm is on the boulder-clay ridge of Foston.

(22) A footpath runs through the village of Foston, constructed also of boulders collected from the adjacent lands. There are at least 3,000 ranging from 1 ft. 6 in. to 6 in. in diameter. They are principally rounded, although a few are angular and subangular. Three-fourths of them are various kinds of sandstone, the remainder being mountain and liassic limestones, a few whinstones, and red, grey, and Shap Fell granites.

NOTE.—An aged woman, some 80 years old, remembers in her girlhood this footpath being constructed by the Rev. Sydney Smith, who induced the farmers to gather them from the land for this purpose for 5*s.* or 6*s.* per load. She assisted personally to gather them, and states that at that time (some 70 years ago) the land was thickly strewed with them. She also stated that at the commencement of the Rev. Sydney Smith's charge the cottage houses in Foston were mainly built of boulders and clay; many of these hovels were pulled down by his orders, and replaced by superior dwellings.

(23) On the same farm, and placed in various positions about the farm buildings, are 20 boulders, varying from 1 ft. 10 in. × 1 ft. 5 in. × 1 ft. 4 in. to 1 ft. 3 in. × 1 ft. × 1 ft.; they are rounded and subangular, and show little traces of any striæ; they are chiefly sandstone and limestone, and have all been collected from adjacent land.

NOTE.—Foston is situated about half-way betwixt York and Malton, and is about a mile W. of the Barton Hill station of the North Eastern Railway.

Thornton-le-Clay.—(24) Near a house occupied by Mr. Spaven (estate of Mr. Weatherell), in the village of Thornton-le-Clay, is a boulder; it is 2 ft. 10 in. × 2 ft. × 10 in. out of the ground; appears to have been

originally rounded, but has weathered away; no striæ or groovings; mountain limestone, with casts of producti and encrinites; it rests on boulder clay, about 150 ft. above sea-level.

NOTE.—This stone was used for mounting purposes in the days of the grandparents of the present occupants.

(25) In front of this house, forming a broad footpath, are about 200 boulders, averaging 8 in. in diameter; they are composed of limestone, whinstone, and sandstone, the latter predominating; they are rounded to subangular, but of course, from wear and tear, no striæ or groovings are now visible.

(26) In the parish of Thornton-le-Clay is a footpath over a mile in length; it is paved with boulders varying from 1 ft. 6 in. × 7 in. × 6 in. to 6 in. in diameter; the footpath is about 4 feet wide, and is flanked by the larger boulders. They are composed principally of Carboniferous sandstone, a few whinstones, granites, and mountain and liassic limestone. Percentage about the following: granite, 1; whinstone, 3; mountain and liassic limestones, 18; Carboniferous sandstones, 78. Generally speaking, they are rounded from usage, but a few of the larger are subangular.

NOTE.—This footpath has a certain degree of celebrity, as it was constructed by the orders of the famous Sydney Smith from stones collected from adjacent fields. It will be remembered that Sydney Smith filled the benefice of Foston-le-Clay (the adjoining village) from 1809 to 1831, and his memory is still green in the neighbourhood.

(27) About the centre of the village of Thornton-le-Clay (nearest railway-station is Flaxton, N.E. of York) is a boulder forming a corner-stone in Mr. Danby's timber-yard, 2 ft. 5 in. × 1 ft. 7 in. × 1 ft. 8 in. out of ground; subangular; has been moved to its present position; no striæ or groovings; mountain limestone; now rests upon boulder clay and gravel, 150 feet above sea-level.

Group.—(28) In the parish of Thornton-le-Clay, upon farms in the occupation of Messrs. John Buckton and W. Spaven, and also upon premises occupied by Mr. Danby, are upwards of 1,100 boulders. The largest measures 2 ft. × 1 ft. 11 in. × 10 in., the smallest being 10 in. × 9 in. × 6 in. They are principally subangular to rounded. The whole of these have been taken from the adjoining fields, and are now in heaps for mending of the roads, &c. No striæ were observed. They are chiefly composed of mountain limestone, Carboniferous sandstone, lias, basalt, and granite. They were derived from boulder clay and gravel, 150 ft. above sea-level.

(29) At the east end of the village of Thornton-le-Clay is a boulder on the roadside, 1 ft. 8 in. × 1 ft. 4 in. × 2 ft. out of ground; subangular; long-shaped; no striæ now visible (it has been used for years as a mounting-block); mountain limestone; about 250 feet above sea-level; is the boundary stone between Thornton-le-Clay and Foston, and has been, according to tradition, the scene of many disputes between the inhabitants of the two villages.

NOTE.—The country around is slightly undulating. Thornton-le-Clay is built upon a flat, broad ridge of boulder clay.

Staxton, near Scarbro'.—(30) In the centre of the village of Staxton (parish of Willerby) is a boulder close to the horse-trough. It is 1 ft. 10 in. × 1 ft. 2 in. × 1 ft. 5 in.; subangular; has been moved; no striæ or groovings; Carboniferous sandstone. It is said to be one of

many blocks which were carted from the adjoining fields a generation or two ago for road repairs, corner-posts, cheese-presses, &c. It rests upon mixed gravels, 150 ft. above sea-level.

(31) At the junction of two roads in the village of Staxton is a boulder, on the estate of Mr. Rivis. It is 2 ft. × 2 ft. × 1 ft. out of the ground; rounded; has been moved; no striæ or groovings; dark blue whinstone; about 120 ft. above sea-level; was originally brought from one of the numerous hillocks in the Carrs below, which are composed of boulder clay, sand, and gravel.

NOTE.—Staxton village is about three miles south of Seamer railway-station, near Scarbro', and is built upon the chalk rubble or talus from the wolds, which form a commanding range above the village.

Flixton, near Filey.—(32) In the village of Flixton (parish of Folkton), about six miles N.W. of Filey, is a boulder forming a corner-stone in the garden of Mr. Coxworth, on the estate of Mr. Wilson of Malton. It is 2 ft. 9 in. × 1 ft. 10 in. × 11 in.; in shape a rounded oblong; has been moved; no striæ or groovings; Carboniferous sandstone; about 150 ft. above sea-level; the subsoil is sand mixed with chert.

Group.

(33) In the village of Flixton the following boulders form a protection around the spring-head. (This spring is one of the numerous ones flowing from the lower chalk in this vicinity.)

1 ft. 11 in. ×	1 ft. 4 in. ×	1 ft. 1 in.	Coarse dark brown sandstone.
2 ft. 3 in. ×	1 ft. 10 in. ×	11 in.	Fine-grained light red sandstone.
1 ft. 9 in. ×	1 ft. 6 in. ×	1 ft. 0 in.	Mountain limestone.
1 ft. 6 in. ×	1 ft. 1 in. ×	6 in.	Hard sandstone.
3 ft. 7 in. ×	1 ft. 11 in. ×	9 in.	Close-grained hard sandstone.
2 ft. 7 in. ×	1 ft. 4 in. ×	6 in.	Light red sandstone.
1 ft. 2 in. ×	10 in. ×	8 in.	Whinstone.

They vary from angular to rounded; the mountain-limestone block shows striæ in the direction of its longest axis, the others are smoothed without striæ; tradition states they have been brought from the Carrs about a mile below. (The Carrs are principally composed of peat bog, with here and there hillocks of boulder clay and gravel, from which boulders are obtained at the present day.) The district is about 120 ft. above sea-level.

(34) *Hunmanby.*—The corner-stone at the junction of Bridlington Street and Garton Lane in Hunmanby village is a boulder 3 ft. 3 in. × 2 ft. 10 in. × 1 ft. 9 in.; subangular; no striæ or groovings observed; a fine-grained light brown sandstone; about 100 ft. above sea-level.

(35) In the village of Hunmanby are various boulders. Near the Hull are:—

1 ft. 8 in. ×	1 ft. 7 in. ×	11 in.	Dark red sandstone.
1 ft. 4 in. ×	1 ft. 2 in. ×	1 ft. 0 in.	Coarse, gritty red sandstone.
1 ft. 5 in. ×	1 ft. 0 in. ×	1 ft. 0 in.	Whinstone.
1 ft. 6 in. ×	8 in. ×	6 in.	„
1 ft. 2 in. ×	10 in. ×	4 in.	„
1 ft. 8 in. ×	1 ft. 0 in. ×	8 in.	„
1 ft. 9 in. ×	11 in. ×	10 in.	„
2 ft. 4 in. ×	2 ft. 3 in. ×	1 ft. 3 in.	„
1 ft. 10 in. ×	1 ft. 8 in. ×	11 in.	„

Corner of Scarbro' and Driffield roads are four boulders varying from

3 ft. 4 in. × 1 ft. 8 in. × 1 ft. to 1 ft. 9 in. × 1 ft. 2 in. × 7 in.; these are sandstones and whinstones.

South of village is a boulder of red sandstone 1 ft. 11 in. × 1 ft. 10 in. × 1 ft. 9 in.; close by, one of dark brown sandstone 1 ft. 6 in. × 1 ft. 7 in. × 8 in.; they are principally rounded and subangular; could not observe any striæ or groovings; about 100 ft. above sea-level.

Note.—Hunmanby is on the east slope of the Yorkshire wolds, and on the line of fault running nearly N. and S., one half of the village thus being upon the Speeton or Neocomian clays, the other part more or less upon the lower chalk.

Bridlington.—(36) In the parish of Bridlington, on the estate lately purchased by the churchwardens, and occupied by Mr. Taylor, and situated in Applegarth Lane, about 100 yards S.E. of the Priory church, occur a number of boulders, viz.:—

5 ft. 0 in. × 1 ft. 10 in. × 1 ft. 4 in.	Elliptical.	Sandstone.
3 ft. 0 in. × 1 ft. 10 in. × 1 ft. 1 in.	Angular.	Sandstone (fine-grained).
3 ft. 3 in. × 2 ft. 10 in. × 1 ft. 11 in.	Rounded.	Whinstone.
2 ft. 6 in. × 2 ft. 4 in. × 1 ft. 4 in.	,,	,,
1 ft. 10 in. × 1 ft. 9 in. × 1 ft. 4 in.	,,	Sandstone.
2 ft. 0 in. × 1 ft. 8 in. × 1 ft. 0 in.	Subangular.	Whinstone
3 ft. 4 in. × 1 ft. 8 in. × 1 ft. 2 in.	,,	Light red sandstone.
2 ft. 8 in. × 2 ft. 3 in. × 1 ft. 5 in.	,,	Shap Fell granite.
3 ft. 11 in. × 2 ft. 2 in. × 1 ft. 7 in.	Angular.	Sandstone.
2 ft. 10 in. × 2 ft. 3 in. × 1 ft. 7 in.	,,	,,
2 ft. 9 in. × 1 ft. 8 in. × 1 ft. 3 in.	,,	Whinstone.
2 ft. 11 in. × 2 ft. 1 in. × 1 ft. 2 in.	,,	Fine-grained light brown sandstone.
2 ft. 11 in. × 2 ft. 2 in. × 10 in.		A flat slab of dolerite.
2 ft. 9 in. × 1 ft. 9 in. × 1 ft. 0 in.	Rounded.	Sandstone.
1 ft. 3 in. × 1 ft. 0 in. × 7 in.	,,	Shap Fell granite.
2 ft. 8 in. × 2 ft. 2 in. × 1 ft. 6 in.	,,	Sandstone.
2 ft. 6 in. × 1 ft. 9 in. × 1 ft. 5 in.	,,	Mountain limestone.
2 ft. 0 in. × 1 ft. 4 in. × 1 ft. 0 in.	,,	Sandstone.
1 ft. 3 in. × 1 ft. 0 in. × 8 in.	Subangular.	,,

They are all exposed on the surface, and have been collected from adjacent fields; no striæ or groovings are now visible; about 100 ft. above sea-level. The underlying deposits are principally gravel, but further details as to the geology of this district will be found in Mr. Lamplugh's memoirs.

East Lutton.—(37) In the village of East Lutton, on the Yorkshire Wolds, there is a boulder in the stackyard of Mr. Pexton (estate of Mr. T. J. Bell). It is 2 ft. × 2 ft. × 1 ft. 1 in.; subangular; has been moved; there are traces of striæ and four or five groovings (about $\frac{1}{8}$ in. deep) across its shortest axis; hard blue whinstone; it was formerly on the side of Park Lane in this village, but had been the subject of litigation between successive road surveyors, until removed to its present harmless position.

Note.—East Lutton is at the bottom of a wide deep valley, the chalk hills rising to a height of nearly 600 ft. on each side.

Driffield.—(38) In the Roman Catholic churchyard in the town of Driffield is a boulder. It is 2 ft. 10 in. × 2 ft. 6 in. × 1 ft. 4 in. out of the ground; subangular; has been moved; no striæ or groovings; hard blue whinstone.

Note.—It is said that a gentleman who lived formerly in the house next to the church had it placed there as a stepping-stone, and obtained it from the clay excavated in the construction of the Driffield Canal.

(39) On Mr. Holtby's estate, about 150 yards east of Driffield parish church, are a number of boulders.

Twelve of these average 1 ft. × 10 in. × 8 in.; subangular to rounded; their composition was mountain and liassic limestones, red granite, whinstone, and Carboniferous sandstone, the latter having the largest percentage; no striæ or groovings were observed; they had been derived from the boulder clay which overlies the upper chalk in this district.

NOTE.—This boulder clay has a wide difference in composition and texture, and occurs in patches. Some is of a hard, tough, blue nature, whilst others are light red to cream-coloured, with a large percentage of sand, and a sprinkling throughout of rounded chalk pebbles and angular flints. The latter species of clay are covered with about 5 feet of gravel.

Reighton, near Filey.—(40) On the farm occupied by Mr. Beauvais, about half a mile from the coast, is a boulder. It is 2 ft. 6 in. × 1 ft. 6 in. × 1 ft. 6 in. out of ground; subangular; no striæ; dark blue whinstone; about 50 ft. above sea-level; was taken out of a bed of boulder clay overlying gravel in the neighbourhood.

Rev. R. A. Summerfield, Vicar of North Stainley, furnishes the following reports upon boulders near Tanfield:—

In parish of West Tanfield, on left bank of river Ure, long. 1° 33′ 55″, lat. 54° 11′ 47″, is a large boulder 12 ft. 6 in. × 7 ft. × 1 ft. 9 in. above ground; triangular; it has never been moved by man; its longest axis is N.N.E., S.S.W.; it is highly polished, with a few slight striæ on the sides in the direction of longest axis; mountain limestone, containing numerous specimens of producti and turbinolia; it is embedded in gravel, which I removed to the depth of 18 inches, without finding the base of the boulder.

On a little green outside the village of Thornborough is a boulder, long. 1° 33′ 10″, lat. 54° 12′ 41″, 3 ft. 9 in. × 2 ft. 5 in. × 1 ft. 10 in. Subangular with rounded ends; was removed to its present position about 50 years ago, from a field in the vicinity; top and sides smooth but not striated; fine gritstone.

Mr. W. F. K. Stock, F.C.S., F.I.C., public analyst for the County of Durham, reports upon the Greystone, Manfield, N. Riding:—

This boulder is in the parish of Manfield, Stanwick Estate, and on the Greystone Farm (so called after the boulder), the nearest town being Darlington; 12 ft. 1 in. × 5 ft. 6 in. × 3 ft. 4 in.; subangular; longest axis N.N.W. by S.S.E.; its surface weathered to such an extent as to render character of markings very doubtful. Felspathic trap; specific gravity, 2·66. Its analysis gives—

Silica	59·87
Alumina	16·17
Protoxide of iron	3·60
Peroxide of iron	1·83
Protoxide of manganese	0·43
Lime	4·57
Magnesia	3·35
Potash	1·48
Soda	2·73
Carbonic acid and water	6·50
	100·53

Although well known as the 'Greystone' no legend is known to be

connected with it. It is isolated and entirely exposed on the bank of a small rivulet. It rests upon boulder clay.

Rev. E. M. Cole, M.A., Wetwang, President of the Geological Section of the Yorkshire Naturalists' Union, describes the following boulders at Neswick, in the parish of Bainton, East Riding:—

No. 1 was found in a field, 250 yards E. of Bracken Road, and distant from Neswick Farm about $\frac{1}{3}$ of a mile. It interfered with ploughing, hence dug out; attempts have been made to break it up, and three barrow-loads of the block were removed by hammers. The present size is 4 ft. × 3 ft. × 1 ft. 6 in. It is very compact; one side has a joint face; edges sharp, rest rounded.

No. 2 is 2 ft. 9 in. × 2 ft. 4 in. × 1 ft. 4 in.; rectangular; surfaces fairly flat.

No. 3 is 1 ft. 6 in. × 1 ft. 6 in. × 1 ft.

No. 4 is 2 ft. × 2 ft. × 1 ft.; the two latter were excavated in the railway-cutting passing through the same field.

All the above are basalt.

There is also a block of siliceous limestone 1 ft. 6 in. × 1 ft. × 1 ft.

Mr. William Watts, F.G.S., of Rochdale (engineer to the Oldham Corporation Waterworks), reports upon erratics on the west of the Yorkshire Pennines (South-West Riding of Yorks):—

In the Strinesdale Valley is a large variety of boulders intermixed with boulder clay and the upper gravels. Silurian grits predominate, then the syenites from the lake district; also mountain limestone, quartzites, and trap. Along with these are local grits, mostly gannister, all of which are much rounded, especially the smaller ones, and many are striated.

The erratics are not large, 2 ft. × 2 ft. × 1 ft. 6 in. being a fair average. They are well rounded; a few are subangular, but I have not found any quite angular. Some are striated on one side. The pebbles are numerous, almost legion, foreign and local, making a splendid gravel but for some black shale intermixed.

Note.—As you ascend this valley the right hand is in the South-West Riding of Yorkshire.

The hills rise to an altitude of nearly 1,200 feet above sea-level. The area examined lies between the 740 and 830 feet, Ordnance datum. Character of strata—Lower Coal Measure shales.

Physical features—gently sloping valleys and rounded hills.

In the Castleshaw Valley few boulders have as yet turned up; those which have been gathered are small syenites, about 12 inches square, and silurian grits. The syenites are round, but the silurian grits are angular, one specimen (1 ft. 8 in. × 1 ft. 3 in. × 8 in.) having very sharp angles. Small Eskdale granites turn up occasionally, much worn as usual. One specimen of silurian grit in my possession is nicely striated and smoothed.

Near Waters's Mill an isolated erratic lies in the middle of a small field, 4 ft. 6 in. × 2 ft. 6 in.; hornblendic trap; elongated and subangular; longer axis trends south-west; upper face only exposed.

Notes.—This valley is carved in the Yoredale shales. The surrounding hills are capped with Kinderscout grit. Grey shale, fully 250 feet thick, lies between the Kinderscout and the hard and somewhat massive Bakestone shale, which is unchanged in character for more than fifty feet without coming to its base. The hills at the top of the valley rise to

1,300 feet above the sea. The hills at the bottom end of the valley are mamillated. The slopes are gentle.

This valley is recent, and conclusive evidence of a former lake exists which had a large area. Boulder clay none; local clay and loam, an ample supply. Coarse gravel in the centre of the valley at one place, 14 ft. thick; sand about 3 ft. thick; both freshwater, and partially lacustrine. A few pebbles.

Area examined between 700 and 1,200 ft, Ordnance datum.

I found in the Denshaw Valley a number of boulders at New Year's Bridge, 940 ft. above sea-level. They averaged 2 ft. 6 in. × 1 ft. 9 in. × 1 ft. 6 in., and consisted of syenites and diorites. I have found no traces of striæ on any of the boulders, which are all rounded except one or two. I found no isolated boulders.

NOTES.—This valley is carved in the Third Grits of the Millstone Grit series.

The hills rise to an elevation of 1,500 to 1,600 ft. above sea-level. The valley in the main is deep and tortuous, and the hills mostly saddle-backed.

Vegetation dwarfish and scanty; very few trees exist; the winds are too strong, and the climatic conditions generally are too severe for tree-growth; besides, the soil is scanty and wet.

Boulder clay is absent above the 850 ft., Ordnance datum. Gravel is also absent, and no sand worth the name is met with. Pebbles are few. Valley alluvium coarse and scanty. The Yoredale shales crop out at Rag Stones and Readycon Dean; at the latter places the shales are very carbonaceous and much-faulted.

Area examined between the 850 and 1,268 ft. Ordnance datum.

The Boulders of Robin Hood's Bay are reported upon by S. CHADWICK, *F.G.S.*, *and* C. BROWNRIDGE, *F.G.S.*

Group No. 1.—On each side of the principal street running through the village of Baytown are the following boulders, which have been removed from the adjacent boulder clay resting on the Lower Lias.

Twenty-four of whinstone, varying from 2 ft. 7 in. × 1 ft. 9 in. × 1 ft. 2 in. to 1 ft. $1\frac{1}{2}$ in. × $11\frac{1}{2}$ in. × 7 in. Subangular.

Two of sandstone (possibly Moor grit), 1 ft. 1 in. × 1 ft. × 10 in. and 2 ft. 1 in. × 1 ft. × 1 ft. 5 in. Subangular.

One of Gritstone.	1 ft. 9 in. × 1 ft.	5 in. ×	9 in.; rounded.
Three of Mountain Limestone.	1 ft. 7 in. × 1 ft.	4 in. × 1 ft.	3 in.
	1 ft. 6 in. × 1 ft.	3 in. ×	10 in.
	2 ft. 2 in. × 1 ft.	8 in. ×	10 in.; all subangular.
One of Dolerite.	2 ft. 2 in. ×	11 in. × 1 ft.	10 in.; rounded.

Group No. 2.—Lying in the bed of the stream that passes through the village are three boulders—

2 ft. 8 in. × 2 ft.	1 in. × 1 ft.	6 in.;	Sandstone (possibly Moor Grit); subangular.
4 ft. 1 in. × 2 ft.	6 in. × 1 ft.	2 in.:	Felstone; rounded to subangular.
1 ft. 10 in. × 1 ft.	6 in. ×	8 in.;	Sandstone or Quartzite; rounded.

Group No. 3.—Lying in the valley of Mill Beck, about half a mile south of the village, are four boulders—

1 ft. 3 in. × 1 ft.	×	11 in.;	Sandstone (possibly Moor grit); subangular.
3 ft. 4 in. × 2 ft.	× 1 ft.		„ „ rounded.
1 ft. 7 in. × 1 ft.	2 in. ×	9 in.;	Gneiss, or gneissose granite; subangular.
3 ft. 6 in. × 2 ft.	8 in. × 2 ft.	2 in.;	Whinstone; subangular.

The boulders of the second and third group have been exposed by the washing away of the boulder clay, and in some cases have evidently rolled down from slightly higher elevations to their present positions.

The following Shap granite boulders at Marton-cum-Grafton are reported upon by Rev. E. P. Knubley, M.A. (Vicar of Staveley):—

At Marton-cum-Grafton, 3 miles S.E. by S. from Boroughbridge, are two Shap granite boulders.

No. 1 measures 3 ft. 3 in. × 3 ft. 1 in. × 2 ft. 6 in.; greatest girth 9 ft. 9 in.
No. 2 „ 2 ft. $5\frac{1}{2}$ in. × 2 ft. 6 in. × 1 ft. 8 in.; „ 8 ft.

Both are rounded; no grooves or striations; they have been moved from a narrow lane leading to Scruddle Dyke Pond, at the bottom of the village, to the Vicarage Gardens. Their former position is about 100 ft. above sea-level. There are long ridges of gravel in the parish.

NOTE.—Shap Fells are 64 miles N.W. of Marton.

Reports upon Boulders at Staveley, Arkendale, and Claro Hill are given by Rev. E. P. KNUBLEY, *M.A.*

At Staveley, which is three miles S.W. of Boroughbridge, and 100 ft. above sea-level, there are on either side of the church, ridges of gravel, which run parallel to the Ure on the one hand, and the Nidd on the other. The gravel, which covers about ten acres, consists for the most part of rounded sandstone, interspersed with a small proportion of Carboniferous limestone, ranging from the size of a small pebble to a block 2 ft. 5 in. × 2 ft. × 2 ft. The smaller of these are rounded and polished, the larger subangular. The latter show numerous fine striations which run parallel with the longer axis. The lower Wensleydale series, to which the larger rocks belong, is about 25 miles to the N.W. I have found one piece of Shap granite which was round and about a foot long.

At Arkendale, which lies 4 miles due south of Boroughbridge, and about 180 ft. above sea-level, there are several erratic blocks of Carboniferous limestone. The largest of these, which lies by the road-side, within 20 feet of the east end of the church, is 3 ft. 8 in. × 3 ft. 2 in. × 2 ft. 6 in., and is subangular.

Claro Hill, the mound from which the wapentake is named, is composed entirely of glacial drift of the same character as that found at Staveley, except that the pebbles of mountain limestone are more numerous and more polished. This mound, which is rather more than four miles south of Boroughbridge, is situated at the angle formed by the junction of the road from Clareton with that which runs from Wetherby to Boroughbridge. The summit is about 230 ft. above sea-level. The largest boulder at Claro Hill is of mountain limestone, subangular, and is about 4 ft. square.

Mr. William Gregson, Baldersby, Thirsk, reports upon Yorkshire coast boulders:—

On the West Cliff Sands, Whitby, is a boulder of Shap Fell granite. No striæ; subangular; 4 ft. × 2 ft. × 2 ft. 3 in. Is on the shore. Rests upon Lower Oolite.

In Runswick Bay, north of Whitby, are four boulders, three of which are composed of Shap Fell granite, the fourth being of grey granite. They are on the shore; are rounded; without any striæ; and are about 4 ft. across each way; they rest upon Middle Lias.

Mr. Robert Mortimer, of Fimber, reports that at Southburn, near

Driffield, is a boulder; lat. 53° 57′ 45″, long. 0° 29′ 47″. Whinstone, 4 ft. 3 in. × 3 ft. 5 in. × 1 ft. 3 in. Longest axis E. and W. About 100 ft. above sea-level. Is near a chalk pit, a short distance from the new railway between Driffield and Market Weighton. Has not been moved. Is on boulder clay resting upon Upper chalk.

Some large Yorkshire blocks which have been erroneously described as erratics have been examined by the Yorkshire Committee, and, to prevent further errors, their report is subjoined:—

The 'Fourstones' near Bentham.—The 'Fourstones' was reported to the Yorkshire Boulder Committee in 1887 as an isolated boulder, but there were several points of similarity between this block and the 'Hitchingstone.' As the latter had been erroneously reported to the British Association in 1874 by a private individual as an erratic, whereas it was demonstrated in 1887 that it is not one, it was deemed desirable that the 'Fourstones' should be closely examined before a report was forwarded.

Mr. C. D. Hardcastle, Vice-Chairman of the Yorkshire Boulder Committee, has visited it, and thus reports:—

The so-called 'Fourstones' boulder forms a prominent feature in the landscape for some distance in every direction. It stands on the open moor, about two miles south of High Bentham, and within a few hundred yards of Fourstones Farm-house, a shooting-box belonging to the Fosters of Hornby Castle.

The stone is of irregular form, about 10 yds. by 6 yds. in extreme length and width, 29 to 30 yds. in circuit, and nearly 4 yds. high. It is a moderately fine sandstone grit, similar to the stone quarried in several places about Bentham. It appears to be in or near its original position, and at first sight gives the impression of having been tilted, weathered grooves, apparently along bedding lines, crossing the top at the southern end with an inclination towards the south or south-west; but this perhaps may be from false bedding. In composition it is the same as the stone beneath it, as evidenced by an exposed portion in a hollow about 18 yds. distant, generally filled with water.

The 'Fourstones' is evidently a relic of denudation, and there is no probability of its having travelled.

The 'Haddockstones,' near Ripon.—Note by the Yorkshire Boulder Committee.—The attention of the Committee has been called by the Rev. J. Stanley Tute, B.A., Vicar of Markington, to a group of remarkable blocks, which give the name to the farm of Haddockstones, 4 miles S.W. of Ripon. The word 'haddock' is a local name for a shock of corn.

The Chairman and other members of the Committee, accompanied by Mr. Tute, visited the farm on June 1. The blocks are of sufficient size to be visible at a distance of several fields, and lie among a low escarpment of the same rock as that from which they are derived, viz., a sandstone in the Third Grit series. Few of the blocks are undisturbed, and their planes of stratification rarely coincide with the bedding of the rock beneath. Some exhibit apparently modern surfaces, as if pieces had been removed by wedges.

From the position of these blocks along an outcrop of precisely similar sandstone, the Committee consider it likely that they are merely weathered fragments, nearly *in situ*, and concur with Mr. Tute that they cannot be claimed as erratics.

Durham.

Rev. Arthur Watts, F.G.S., &c., Vice-Principal of Bede College, Durham, describes the following boulders in the village of Harton, near South Shields (co. Durham):—

No. 1. At the Ship Inn, nearly opposite the church; 3 ft. 8 in. × 2 ft. 9 in. × 2 ft. 8 in.; greatest circumference (just above ground) 10 ft. 3 in.; subangular, but rounded on top by attrition; has not been moved; no striæ or groovings.

No. 2. The 'Preaching Stone,' opposite the hall; 3 ft. 1 in. × 2 ft. 10 in. × 2 ft. 2 in.; greatest circumference 9 ft. 9 in.; subangular, but rounded on top; no striæ or groovings; has not been moved.

No. 3. In the Back Lane, near the Duck Pond; 1 ft. 10 in. × 1 ft. 6 in. × 1 ft.; no striæ or groovings; has not been moved.

No. 4. In the field on W. side of White Horse Farm; dimensions cannot now be given, as it has been sunk by the farmer to escape the plough. It was too heavy to remove and too hard to break.

There are many smaller ones, in walls or on roadsides, scattered over the parish, varying from the size of No. 3 downwards. They are all of basalt or whinstone, locally called 'blue stone'; the nearest dyke is about 3 miles N., near Tynemouth and Cullercoats; the size of the largest suggests that they may have travelled from the Great Whin Sill. Harton is from 50 to 60 ft. above sea-level. They are seen only when on the surface, but the plough frequently reveals them, and draining still more frequently, so that they occupy the whole of the clay deposit, which covers this area to a thickness which varies greatly in different localities.

Lancashire.

Mr. Chas. E. R. Bucknill, of Rawtenstall, near Manchester, reports as follows:—

An isolated boulder is to be seen on the hill known as Seat Naze, in a pasture-field of Seat Naze Farm, in the parish of Newchurch-in-Rossendale, township of Whalley. The land is the property of Mr. Hargreaves of Blackburn, and is farmed by Dr. Wilson of Newchurch. The boulder is situated on the south side of the hill, about 50 yards south of a circular enclosure of stone, formerly containing some few trees. The greatest length is 5 ft., the greatest width 3 ft. 6 in. The higher and northern end stands 2 ft. out of the ground, the lower and southern end only a few inches. May be described as a foreshortened coffin in shape, the angles being only slightly worn. The boulder has not been moved, and has its longest axis pointing N. and S. There are no ruts, striations, or groovings on the exposed surfaces. The upper surface is concave, but this has not the appearance of being produced by grinding or wearing. The rock is a quartzose volcanic agglomerate from the Borrowdale series. Has long been known as the Bellstone, but for what reason I have not been able to ascertain; is 960 feet above the sea. Is not marked on the Ordnance Survey maps. Perfectly isolated. It rests upon a coarse sandstone, one of the rough rocks of the Feather Edge, which constitutes the upper boundary of the millstone grit.

Third Report of the Committee, consisting of Professors SCHÄFER (*Chairman*), MICHAEL FOSTER, *and* LANKESTER *and* Dr. W. D. HALLIBURTON (*Secretary*), *appointed for the purpose of investigating the Physiology of the Lymphatic System.*[1]

DURING the past year work on the chemical physiology of blood corpuscles and on the proteid constituents of the aqueous humour has been continued by Dr. Halliburton in the Physiological Laboratory of University College, London.

In the two previous reports of the Committee the special subject dealt with has been that of the proteids of the colourless corpuscles, or, more strictly speaking, of lymph cells; that is, the cells obtained from lymphatic glands and also from the thymus gland. Lymph-corpuscles being typical animal cells, this research was in other words directed to the determination of the varieties of proteid that occur in protoplasm. The proteids found were as follows:—

1. A globulin which coagulates at 48°–50° C. *Cell-globulin* (α).
2. " " 75° C. *Cell-globulin* (β).
3. An albumin " 73° C. *Cell-albumin.*
4. A peculiar proteid which swells up into a jelly-like mass with solutions of sodium chloride and magnesium sulphate, and which was found to possess the chemical characteristics of a *nucleo-albumin.*

The special subject investigated this year has been that of the proteids contained in the stromata of the red corpuscles of mammalian (sheep's) blood. The red discs are cellular in origin; the presence of a large quantity of hæmoglobin in them shows that they possess something which is not present in typical cells; the absence of a nucleus shows that they have lost something present in typical cells. The question, however, still remains, How far do the stromata (*i.e.*, the colourless residues after the extraction of the pigment) retain the properties and constituents of unaltered protoplasm?

The quantity of proteid contained in the discs is relatively very small in amount; there are in addition small quantities of lecithin, cholesterin, and inorganic salts, of which the most important is potassium phosphate.

It has, however, been the proteid which has especially engaged our attention, and in investigating this substance Dr. Halliburton has secured the co-operation of Dr. Walter M. Friend, of Boston, U.S.A.

Dr. Friend has also performed experiments in another direction, namely, the constitution of the aqueous humour of the eye.

It will, therefore, be convenient to divide this report into two parts, the first dealing with the stromata of the red corpuscles, the second with the aqueous humour.

THE STROMATA OF THE RED CORPUSCLES.

The method which was found to be the best for the preparation of the stromata was that introduced by Wooldridge.[2] Freshly whipped blood is

[1] This report is written by Dr. Halliburton, by whom, and under whose direction, the work has been carried on.

[2] Du Bois-Reymond's *Archiv f. Physiol.*, 1881, p. 387.

mixed with many times its volume of a 2 per cent.[1] sodium chloride solution, and the corpuscles separated from the salted serum by the use of the centrifugal machine; the mass of corpuscles is then mixed with more salt solution of the same strength, and the process repeated several times. The corpuscles thus ultimately obtained free from serum are mixed with five or six times their volume of water, and a little ether added until the solution is perfectly transparent. The white corpuscles which are unaltered by this treatment sink to the bottom of the vessel, and again the separation may be hastened by the use of the centrifuge. The supernatant fluid is then treated with a 1 per cent. solution of acid sodium sulphate, drop by drop, until the fluid, at first clear, becomes as thick as the original blood. The precipitate which consists of the stromata soon collects into coarse flocculi, which are collected on a filter.

This precipitate is washed free from adherent pigment by a very weak solution of acid sodium sulphate as quickly as possible, as prolonged exposure to this reagent renders the stromata insoluble.

They may then be extracted by saline solutions, such as a 5 per cent. solution of sodium chloride or magnesium sulphate, and these extracts examined by the methods of heat coagulation, and precipitation by neutral salts.

The following are the results obtained:—

1. On heating a saline extract of the stromata there was never the appearance of cloudiness, much less of a precipitate, below the temperature of 60° C. *Cell-globulin α is therefore absent.*

2. *Cell-globulin β*, or cell-globulin, as it will be called in subsequent parts of the paper, *is present*, and is practically the only proteid of the stromata. Its characteristics are as follows:—

a. In solutions containing a minimal amount of salt, or from 5–10 per cent. of magnesium sulphate, it is coagulated at a temperature of 75° C.

b. In solutions containing 5–10 per cent. of sodium chloride, it is coagulated at a much lower temperature, 60°–65° C.

c. It is precipitable from its solutions by carbonic acid, by dialysis, and by saturation with sodium chloride incompletely; by saturation with magnesium sulphate or ammonium sulphate completely.

d. It possesses fibrino-plastic activity—*i.e.*, it has the power of hastening the formation of fibrin in dilute salted plasma, or of pericardial, hydrocele, and similar fluids. Solutions lose this activity when the globulin is removed, or when its characteristic properties are destroyed, as by a temperature of 75° C. The globulin is thus either closely connected to the fibrin ferment, or, as it seems more probable to us, is identical with it.

Stroma-globulin has all these characteristics. Cell-globulin and stroma-globulin are thus probably the same; they resemble paraglobulin (or serum-globulin) in characteristics *a* and *c*. They differ from it in characteristics *b* and *d*.

3. *The stromata do not contain cell-albumin*, or it is only present in the merest traces; this conclusion is arrived at after examining the extracts from which the globulin is removed by saturation with magnesium sulphate.

4. *The stromata do not contain nuclein or nucleo-albumin.*—Neither they nor the unaltered corpuscles swell into a slimy mass on admixture with sodium chloride or magnesium sulphate; lecithin appears to be the only

[1] We found a 1 per cent. solution better to use.

phosphorised constituent of the red discs. This confirms the statement of Hoppe-Seyler,[1] that nuclein is only present in the nucleated red blood corpuscles of the lower vertebrates.

5. *Albumoses and peptones are also absent.*—After the separation of the globulin the extracts were never found to give the characteristic reactions of these substances.

General conclusions.—The mammalian red blood corpuscle is not a cell in the strict morphological sense of the word; it has no nucleus. It is also not a cell in the chemical sense, for not only is nuclein absent, but the only proteid present of the four normally existing in typical cells is cell-globulin, and this exists in the stroma in small quantities only.

The presence of fibrin ferment in the red discs suggests the question whether they contribute to the formation of fibrin in coagulation as it normally occurs in shed blood. There is certainly no necessity to suppose that they shed out any ferment, as they undergo little or no disintegration in shed blood; but it is nevertheless possible that under certain circumstances they may assist in the formation of fibrin, and that Landois' 'stroma-fibrin' may be possibly accounted for in this manner.

Bonne[2] suggests that in cases of disease in which the red corpuscles are disintegrated within the blood-vessels (hæmoglobinæmia), the febrile disturbance that accompanies this condition may be due to the presence of fibrin-ferment derived from the stromata of the discs so dissolved.

The Aqueous Humour.

Chavvas[3] showed that the anterior chamber of the eye must be looked upon as essentially a lymph space, since the formation of the aqueous humour is dependent upon the arterial pressure. Lohmeyer's[4] analyses of aqueous humour are also not antagonistic to the supposition that the fluid in the aqueous chamber is lymph.

Water in parts per 1,000	986·87
Proteids	1·22
Extractives	4·21
Sodium chloride	6·89
Other salts	0·81
	1,000·00

We are, however, not aware that hitherto the individual organic constituents of this fluid have been examined.

The fluid was obtained from the freshly-removed eyes of oxen by means of an ordinary hypodermic syringe. It was clear, colourless, limpid, and free from formed elements.

In most cases it did not clot spontaneously, but sometimes it did so; this was perhaps owing to admixture with blood during its removal from the eye, as in all cases there was a well-marked formation of fibrin on admixture with fibrin ferment or cell-globulin.

This was filtered off, and the filtrate was found to contain a proteid precipitable by saturation with magnesium sulphate, and coagulated by the temperature of 75° C. (serum-globulin). The filtrate also contained a proteid which coagulated at about the same temperature, but which was not precipitable by saturation with magnesium sulphate (serum-albumin).

[1] *Handbuch*, 5th Aufl., p. 429.
[2] *Ueber das Fibrin-ferment.* Würzburg, 1889.
[3] Pflüger's *Archiv*, xvi. 143.
[4] See Gorup-Besanez, *Lehrbuch* (1878), p. 401.

On heating the fresh aqueous humour to 56° C. a precipitate of coagulated proteid was obtained. This is another proof, in addition to the formation of fibrin already mentioned, that aqueous humour contains fibrinogen.

We sought for mucin, but found that it was absent. Albumoses and peptones are also absent.

Kuhn[1] and Gruenhagen[2] have recently described a substance of doubtful nature in the aqueous humour which, like sugar, reduces copper salts, but which is not sugar, as it does not undergo the alcoholic fermentation. We have not made extensive observations in this direction; we can, however, state that in the eyes of the oxen we have examined this substance is not present in sufficient quantities to produce any visible reduction of Fehling's solution, if the aqueous humour be used either fresh or after the separation of the proteids from it by acidulation and heating.

The examination of the proteids of the aqueous humour thus shows that although they are present in small quantities they are in kind like those existing in the plasma of the blood (viz., consisting of fibrinogen, serum-globulin, and serum-albumin); that therefore the supposition that the aqueous humour is, like lymph, an exudation from the blood rather than a true secretion is fully confirmed.

Report of the Committee, consisting of Dr. J. H. GLADSTONE (*Chairman*), Professor ARMSTRONG (*Secretary*), Mr. STEPHEN BOURNE, Miss LYDIA BECKER, Sir JOHN LUBBOCK, *Bart.*, Dr. H. W. CROSSKEY, Sir RICHARD TEMPLE, *Bart.*, Sir HENRY E. ROSCOE, Mr. JAMES HEYWOOD, *and* Professor N. STORY MASKELYNE, *appointed for the purpose of continuing the inquiries relating to the teaching of Science in Elementary Schools.*

THIS year has been one of continued depression in regard to the teaching of science in elementary schools, and of disappointment in regard to legislative action.

The return of the Education Department for this year shows again a diminution in the teaching of the science subjects. The statistics of the class subjects for six years are given in the subjoined table, which shows an actual decrease in elementary science, and a comparative decrease in geography:—

Class Subjects.—Departments	1882–3	1883–4	1884–5	1885–6	1886–7	1887–8
English	18,363	19,080	19,431	19,608	19,917	20,041
Geography	12,823	12,775	12,336	12,055	12,035	12,058
Elementary Science	48	51	45	43	39	36
History	367	382	386	375	383	390
Drawing	—	—	—	240	505	—
Needlework	5,286	5,929	6,499	6,809	7,137	7,424

The return of scholars individually examined in the scientific specific subjects shows an actual or relative falling off in every subject except

[1] Pflüger's *Archiv*, xli. 200. [2] *Ibid.* xliii. 377.

mechanics and chemistry. The figures are given in the following table:—

Specific Subjects.—Children	1882–3	1883–4	1884–5	1885–6	1886–7	1887–8
Algebra	26,547	24,787	25,347	25,393	25,103	26,448
Euclid and Mensuration	1,942	2,010	1,269	1,247	995	1,006
Mechanics A . . .	2,042	3,174	3,527	4,844	6,315	6,961
„ B . . .	—	206	239	128	33	331
Animal Physiology . .	22,759	22,857	20,869	18,523	17,338	16,940
Botany	3,280	2,604	2,415	1,992	1,589	1,598
Principles of Agriculture	1,357	1,859	1,481	1,351	1,137	1,151
Chemistry . . .	1,183	1,047	1,095	1,158	1,488	1,808
Sound, Light, and Heat.	630	1,253	1,231	1,334	1,158	978
Magnetism and Electricity	3,643	3,244	2,864	2,951	2,250	1,977
Domestic Economy .	19,582	21,458	19,437	19,556	20,716	20,787
Total . .	82,965	84,499	79,774	78,477	78,122	79,985
Number of Scholars in Standards V., VI., and VII.	286,355	325,205	352,860	393,289	432,097	472,770

The rapid and serious decrease of attention paid to these science subjects is shown by the percentage of children who have taken them, as compared with the number of scholars that might have taken these subjects, viz:—

In 1882–3 . . . . . . 29·0 per cent.
„ 1883–4 . . . . . . 26·0 „
„ 1884–5 . . . . . . 22·6 „
„ 1885–6 . . . . . . 19·9 „
„ 1886–7 . . . . . . 18·1 „
„ 1887–8 . . . . . . 16·9 „

and it must be remembered that children who have taken two of these subjects count twice over.

The Government laid upon the table of the House a new Code, which would have had a slightly beneficial effect upon the teaching of science; but it has been entirely withdrawn. The Government has introduced no Technical Instruction Bill this year—except just at the last moment—and that does not apply to 'scholars receiving instruction in an elementary school in the obligatory or standard subjects prescribed by the minutes of the Education Department.' It was hurried through the Committee and final stages during the last week of the Session.

Sir Henry E. Roscoe, however, reintroduced his Bill with some modifications, and it passed the second reading at a comparatively early period of the Session; but the Government would only give facilities for its progress through the House on the understanding that very serious changes were to be made in it. As he could not accept these, it has not passed the Committee stage; and it was ultimately withdrawn.

Mr. Samuel Smith has again brought in a Continuation Schools Bill; but there has been no opportunity of discussing it since the first reading, and it was therefore withdrawn. The subject has, however, grown in the estimation of the public; and the whole question of the teaching of science in State-aided schools requires to be pressed more and more upon the legislature.

Third Report of the Committee, consisting of Mr. S. BOURNE, Professor F. Y. EDGEWORTH (*Secretary*), Professor H. S. FOXWELL, Mr. ROBERT GIFFEN, Professor ALFRED MARSHALL, Mr. J. B. MARTIN, Professor J. S. NICHOLSON, Mr. R. H. INGLIS PALGRAVE, *and* Professor H. SIDGWICK, *appointed for the purpose of investigating the best methods of ascertaining and measuring Variations in the Value of the Monetary Standard.*

THE Committee have had under consideration the preparation of an official Index-number which might be employed by parties making contracts with respect to a distant future. They have met repeatedly and discussed the bases of this scheme. They have been in communication with the International Committee, which has been reappointed for two years by the International Statistical Institute. As it is desirable that the subject should receive further consideration, they recommend that they should be reappointed.

MEMORANDUM BY THE SECRETARY.

ANALYSIS OF CONTENTS.

This paper is designed as a supplement to the Memorandum appended to the First Report of the Committee. It will be remembered that the object of that Memorandum was to distinguish the different definitions which the proposed problem might present; and to construct the formula appropriate to each phase of the investigation.

SECTION I.

Professor Newcomb's Method.

One additional definition of the *quæsitum* which has come under the writer's notice since the completion of that Memorandum is that which has been propounded by the eminent mathematician Professor Simon Newcomb, of the Johns Hopkins University. He proposes to measure the variation in the value of the Monetary Standard by the change in the volume of value which is produced by the labour of an average individual in a unit of time.[1] He writes: 'One possible hypothesis would be this. We might assume that the absolute value of everything produced by the population of the country remains unchanged, except that as a population increases the total value produced increases in the same ratio. In other words, we may suppose the average productiveness of each individual to remain the same from year to year.'

Now this hypothesis may appear doubtful in the light of the statistics furnished by Mr. Edward Atkinson and others. There is reason to think that in an improving country the productivity of labour increases. But

[1] *Principles of Political Economy*, Book 3, ch. ii. § 10.

an intelligible rationale can still be assigned to Professor Newcomb's scheme considered as a standard for deferred payments. It may be regarded as just that the debtor should pay, the creditor receive, a constant proportion of the goods produced by an average man's labour. If the productivity of the average man increases, the creditor gains without the debtor losing. The principle may be illustrated by the present writer's proposal (in the former Memorandum) that the standard might be a constant proportion of the average income.[1] It is a principle which appears to be countenanced by some high authorities. Thus Sir Thomas Farrer, in his able Memorandum on *Gold and Credit* prepared for the Commission on the Precious Metals, asks: 'If prices fall, not by reason of any change in the measure of value, but by increased abundance of the things sold, what considerations of justice or of convenience are there which call for an alteration in the measure of value?'

There is, however, a more important difficulty in the way of adopting Professor Newcomb's plan as a standard for deferred payments. Apparently there would be no distinction between articles of immediate consumption and those which are only agents of production; articles of each class would figure equally in the 'value of everything produced' per year. Suppose that the national consumption might be divided into two classes of articles, one consumed nearly raw, the other elaborated through several stages of production, at each of which the transformed material changes hands by a mercantile transaction. Suppose the prices of the former category to rise on an average, while the prices of the latter category—both the long series of materials and with them the finished articles—fall on an average. It might happen that the value-in-use of the same monetary income, say 100*l.*, would remain nearly constant for the average citizen. Yet, according to the new index-number, money might seem to be appreciated. Thus the annuitant or creditor might suffer, as he would receive, say, only 90*l.* or 80*l.* for every 100*l.*, if this scheme were adopted as a standard for deferred payments.

It should seem, then, that for the purpose of deferred payments the scheme contemplated in theory by Professor Newcomb has no advantage over that which he adopts in practice,[2] and which has been described in the former Memorandum: namely, the Consumption Standard. But the conception of quantity of marketable articles produced per unit of economic time may well be valid for some other purpose. What that other purpose is will appear in the following sections.

Section II.

Professor Foxwell's Method.

The conception of quantity produced, or rather sold, per unit of time has been embodied by Professor Foxwell in a distinct definition, which it was an omission on the part of the present writer not to have presented more

[1] Compare the definition of variation in the Monetary Standard which Mr. Giffen implies in the following passage of his important paper 'On Recent Changes in Theories and Prices' (*Journ. Stat. Soc.* Dec. 1888): 'There may be a case of what may properly be described as depreciation of money where prices do not rise. . . . Measured by incomes, though not by the prices of commodities, there may unquestionably in such case be depreciation.' Cf. Professor Walras's conception of a general diminution of the *rarity* (or final utility) of commodities. *Eléments d'Economie politique pure*, Leçon xxxix., § 390.

[2] *Principles*, Book 3, ch. ii. § 11.

clearly in the former Memorandum. Professor Foxwell is understood[1] to regard as the ideal measure of the variation in general prices an Index-number which is based upon all vendible commodities whatever. He would make no distinction between articles of consumption and agents of production. In averaging the respective price-variations he would assign to each an importance proportioned to the corresponding value, or rather to that value multiplied by the number of times it changed hands (in a day, month, or year) by way of a monetary transaction. This plan is regarded as *par excellence* the measure of appreciation or depreciation.

If pressed with the objection which has just been addressed to Professor Newcomb, namely, that the Index-number thus obtained is not the exactest possible measure of the change in the purchasing power of money experienced by the consumer, Professor Foxwell would reply that the consumer is not everyone. The interest of the producer, damnified by appreciation of money, is also to be regarded. The question set to us is a pure currency-question; and the answer to be sought primarily is, not by how much are debts to be scaled up or down, but by how much the metallic currency is to be multiplied in order that the monetary *status in quo* may be restored.

An extreme example may serve to bring out the character of the method. Suppose that the national consumption were divisible into two categories of commodities, the one involving only two mercantile transactions in their production, the other sold or re-sold some twenty times at different stages of its production. Suppose the prices of the former class drop on an average five per cent., while those of the latter drop as much as fifteen per cent., other things, and in particular the National taste, remaining constant. Then, according to the Consumption Standard, the Index-number will be of the form $\frac{\frac{1}{2}\times 95+\frac{1}{2}\times 85}{\frac{1}{2}+\frac{1}{2}}$; that is 90. But the new Index-number may be written $\frac{\frac{1}{2}\times 2\times 95+\frac{1}{2}\times 20\times 85}{\frac{1}{2}+\frac{1}{2}\times 20}$; that is approximately 86. This is not a Tabular Standard adapted to the interest of creditors and annuitants. It is the measure of the seriousness of appreciation for the community.

It will be observed that the example derives its force from the occurrence of a displacement in the rates of exchange between two classes of consumable articles; for without such displacement, if the drop of price in both categories were the same, there would be no difference between the results of the contrasted methods. Now (it may be said) such displacement is not one of the evils which 'laws and kings can cause or cure.' Let debtors and creditors regulate their private affairs by a special Index-number if they like. That is not the affair of statesmen and financiers. But currency *is* within the province of government. It is competent to governments so to augment the currency, that the appreciation accused by the proper Index-number may be reduced.

It should be explained that this scheme does not commit its propounder to any of the extreme views which in the former Memorandum[2] were connected with the conception of amount of sales and the work which gold has to do. He is not bound to refer to the quantity of gold

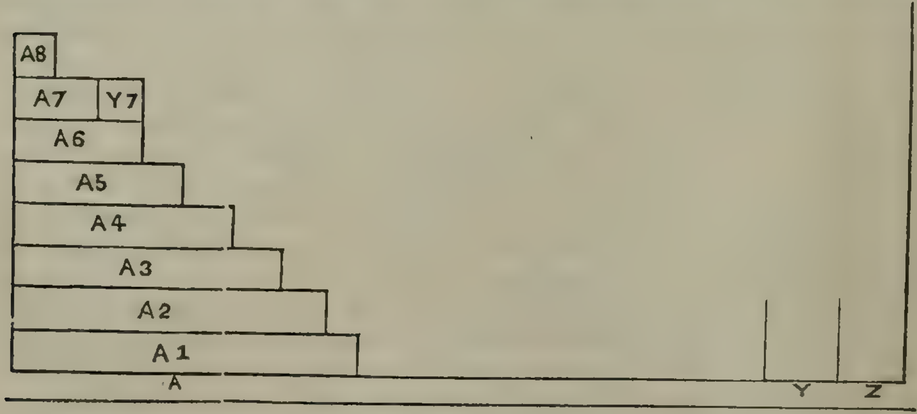
[1] The present writer is responsible for the exposition and illustration of the views which he has obtained in the course of repeated conversations with Professor Foxwell.

[2] Section IX.

actually existing in currency, or relative to an initial epoch. He need not pretend to calculate the amount of gold in use as money at present, or at the initial epoch. He need not pretend to calculate the ratio in which the quantity of gold at the initial period requires to be multiplied in order to equate the present with the original level of prices. He need not state the amount which for that purpose should be added to the present currency. What he professes to obtain is that ratio in which, if the quantity of currency were increased, other things remaining constant during the increase, the level of prices would be restored. But the amount of coin to be actually added is not necessarily deducible from the ratio thus conceived; because (1) the quantity of precious metal in use as money may not be ascertainable with any degree of precision, and (2) other things, in particular the condition of credit, may alter during the process of augmentation. In short our Professor is not to be confounded with the currency-quack who pretends to calculate the exact dose of currency which ought to be administered in order to keep the circulation in a healthy condition. Professor Foxwell's Index is rather of the nature of a diagnosis than a prescription; or at least it only enables him to prescribe the general character of the treatment—whether increased aliment or depletion—but not the exact quantity to be taken.

The *Currency Standard*, as Professor Foxwell's special *protégé* may be designated, is to be distinguished as follows from the *Consumption Standard*, which the Committee, in their collective capacity, have favoured. According to each method, the variation in the value of money is measured by a change in the monetary value of a certain quantity of commodity, supposed to be constant. But the standard quantity is not the same for the two methods. The choice is between the sum of valuables consisting of all the finished goods which pass into the hands of the consumer yearly, and that consisting of all goods whatever which change hands yearly. The basis of the one standard is, to use a bold phrase, the mass of final utility; the basis of the other standard is, to use a bolder phrase, the momentum of final utility.

The choice between the Consumption and Currency Standards may perhaps be assisted by a parable. Let us imagine a new game called *Trade and Industry*. It is to be played with pieces, something like chessmen,



upon a very imperfect sort of chessboard, represented in the above figure. As in chess pawns become queens when they reach that base towards which they move, so in this game, the pieces trend towards the

base line AZ; on reaching which they become, as it were, consummated. But here, at each step in advance, a piece becomes transformed to one of higher value; and the final or consummating transformation is not to a higher piece, but to an actual prize, say a certain number of sugar-plums, which are distributed among the children who take part in the game, according to laws which will be described.

The players in this commercial chess are very numerous. There is, at least, one player to each of the compartments, whereof a few only are shown in the figure; each player is against all the rest. For instance, in the column designated A there are eight compartments (there might be many more), each under the care of at least one independent player.

We may suppose, initially, a pawn at the compartment A_8 (the eighth above the part of the base-line marked A). Player A_8 moves his pawn to compartment A_7, and receives in exchange for that pawn from player A_7 a counter, or rather a batch of, say, five counters. Player A_7 is entitled to replace that pawn by a higher piece, a two-pawn piece, which he (having received one pawn) is competent to produce. This two-pawn piece is passed on by player A_7 to player A_6 in exchange for two batches of counters. Thus the volume of value, like a snowball, rolls on, increasing; until A_1 parts with an eight-pawn piece, or queen, for eight batches of counters.

So far there is a continual stream of pieces downwards and of counters upwards. But now sets in a contrary movement. For the queen are substituted eight sugar-plums, which are transmitted to the players, each plum in exchange for a batch of five counters. There is thus a stream of sugar-plums upwards and of counters downwards.

The game, or turn, being finished, the initial pawn is again produced from limbo, and again exchanged for a unit batch of counters; and so the great Wheel of Trade revolves.

That is confining ourselves, for the purpose of description, to one column. In reality it is to be thought that many of the pieces move, like knights or bishops, in a skew direction. Thus the pawn in the compartment Y_7 immediately on the right of A_7 is not to be considered as the head of a stream which descends straight down to the base, culminating near A. The piece which starts in the compartment mentioned may move off to the right, and, joined perhaps by some other stream, 'queen' at Y.

Now, suppose that, in the course of time, the number of players and pieces have increased, and that the managers of the public place of entertainment in which this game is played have failed to provide a proportionately increased number of counters. It might become necessary to economise counters by using *four* instead of five as the unit-batch, the counters being thus appreciated by 20 per cent. Or, if the change were brought about less symmetrically, by a gradual irregular contraction, the question might arise, How is the appreciation to be measured? What is that ratio of decrease to correct which is the business of the managers; that ratio which, being brought up to unity, we may say to the replenishers, 'Hold, enough'?

There are two views before us. We may measure the appreciation of counters either by the change in the value of the *sugar-plums* which are eaten, or in that of the *pieces* which are put in motion in each game or turn of the wheel.

Suppose there were a set of outsiders, too young or too old, too wise,[1] or who thought themselves too grand to take part in the game, but do not refuse to accept a pension from the bounty of the players—a pension enjoyed in sugar-plums but paid in counters. For this class, certainly, it would be most convenient that the appreciation should be based upon sugar-plums, so that pensions should afford a constant value in use. But in the interest of the actual players, puzzled and damnified by the change of denomination, ought not the measurement to be grounded on the *pieces*? It is tenable that the ratio in which the number of counters should be increased is (the reciprocal of) the ratio of the total value in counters of the whole number of pieces moved in a game at the first period at the rate then prevailing, and the total value of the same pieces at the rate prevailing in the second period.

Suppose that the counters consisted of two sorts, one metal and the other paper, exchanging indiscriminately with each other, and with pieces and sugar-plums, yet demarcated by some material differences. In particular the metal symbols are more under the control of the managers; while the paper tickets are provided by the players themselves. Should the appreciation be expressed by the deficiency in metal counters, or in counters generally? *Primâ facie* surely in terms of the latter, though, as indicating the duty of the managers, the result may sometimes be expressed as a deficiency in metal; in terms of dose rather than diagnosis.

Upon the whole, it appears that the Currency Standard deserves more attention than it has received. The stone unaccountably set aside by former builders of Index-numbers may become the corner-stone of future constructions.

It is not to be thought because the proposed method is likely not to be so revolutionary in practice as it is distinctive in speculation,[2] that therefore it is unbefitting a separate and high place here. For we are concerned here with distinctions of method rather than differences of result. There is attempted here—to illustrate small things by great—for a particular province of industry, the sort of analysis which an eminent member of our Committee has performed upon the 'Methods' of conduct in general. In the sphere of Finance, as well as Ethics, theoretical distinctions are important, although they may not correspond in practice to such marked discrepancies as might have been expected.

Nor is it a fatal objection to the scheme that it would be impossible to ascertain with precision the proportions in which each commodity absorbs, or exercises a pull upon, the currency; that here the number of resales, and there the exceptional use of credit, would defy calculation. For, regarding the proposed Index-number as a Weighted Mean of numerous given variations of price, we see that the objection amounts to saying that the weights are liable to a considerable error. But, as shown in a former Memorandum, and to be insisted on again in the present one, the erroneousness of the weights is likely to produce much less error in the computed mean than might have been expected.

[1] The most direct application of the Consumption Standard is in the interest of annuitants, fellows of colleges, and those whom Mill calls 'idle' landlords.

[2] Thus the example which we have imagined is probably an extreme one; yet it presents a difference between the compared Index-numbers of only seven per cent.; which, in view of the 'probable error,' say two or three per cent., to which *any* Index-number is liable, cannot be considered as colossal.

Nor is it to be objected that, in the present state of statistics, it would be impossible to obtain returns under several of the headings, that many important articles would have to be omitted altogether. For the plan still may present an ideal in the direction of which it may be thought advisable to move as far as possible. It may supply a rationale to some practical method. Thus, any large aggregate of miscellaneous articles, finished and unfinished, may be regarded as a sample taken at random from the immense incalculable series which forms the data of the ideal Index-number. For instance, such a sample may be afforded by the statistics of foreign trade, which we now proceed to consider.

Section III.

Mr. Giffen's Methods.

The next solution of our problem which calls for some additional remarks is that which is deduced from the Statistics of Foreign Trade. It is proposed first to examine the principles upon which Mr. Giffen's masterly calculations are based.[1]

The primary object of the whole investigation appears to have been to compare the volume of trade in different years.[2] The purpose is, in the language of this Committee's first report, to enable us, 'given the increase of value [of exports or imports in one year as compared with another], to estimate the increase in quantity of the class of commodities under consideration.'

But there is room for casuistical discrimination when we inquire what is the meaning and measure of increase in the volume of trade or quantity of commodities.

At first sight the following method of comparing the volume at different epochs might seem plausible. Compare the (given) quantity of one article, say a, in one year, say year x, with the quantity of the same commodity in the compared year y. We thus obtain a ratio

$$\frac{\text{Quantity of commodity } a \text{ in year } y}{\text{Quantity of commodity } a \text{ in year } x}.$$

Form now a similar ratio for article b, and again for c, and so on. The circumstance that the unit of a is avoirdupois, that of b, it may be, liquid measure, and so on, need not clog these calculations of ratio. We shall thus obtain as many ratios as there are articles, say fifty, as approximately in some of Mr. Giffen's computations. Now take the mean of these fifty ratios. That mean ratio represents the variation in the volume of trade between the years x and y.

This solution of the problem is by no means to be despised as *naïf.* It presupposes no doubt a certain sympathy and conformity to a common type on the part of several augmentations of which an average is taken. But it will be shown first that this hypothesis is adequately verified; and secondly, that it is equally postulated by the more familiar solutions of the problem.

As to the first point, consider the following figures, which are obtained by dividing the quantity of every export in 1883 by the corresponding

[1] *Parl. Papers*, 1878–9, C 2247; 1880, C 2484; 1881, C 3079; 1884–5, C 4456.
[2] Consider the title and introductory sentences of the Reports.

quantity in 1880. The quantities are taken from Mr. Giffen's Table V., Part I.;[1] and the quotients are given in the order in which those quantities occur. Thus for *Alkali* the quantity (of cwts.) is for 1880, 6,888, and for 1883, 6,947; the figures after the first four being neglected. Accordingly, the quotient is 1·01, or 1·0. The figures are true to the first place of decimals.

Ratios of Quantities in 1883 to Quantities in 1880	Continued	Continued	Continued
1·0	0·6	1·1	1·2
1·4	0·8	1·0	0·9
1·0	1·2	1·1	1·4
1·1	1·0	0·4	1·0
0·9	1·0	1·0	1·0
2·2	1·1	0·7	1·3
1·3	1·4	1·3	1·2
1·0	1·1	1·1	1·1
1·1	0·9	0·9	1·3
1·4	1·3	1·1	0·9
1·2	1·2	1·1	1·0
1·2	1·2	1·3	1·0
1·4	1·1	1·2	1·2

The grouping of these ratios is exhibited in the annexed diagram; where each upright line, surmounted by a figure expressing its length, represents the number of times that a certain ratio occurs. Thus the ratio 1·1 is presented eleven times; the ratio 1·2 ten times. The median is 1·1; a result which agrees with that obtained by Mr. Giffen's more elaborate and accurate method. He, in effect, weighting each of these ratios with the values of the corresponding article for 1883, finds for the ratio of the volume of 1883 to the volume of 1880 the quotient $146{,}371{,}015 \div 138{,}032{,}674 = 1{\cdot}06$, or approximately 1·1.

Again, comparing 1886 with 1883, and taking each of the fifty-two ratios to two decimal places, I find for the median 1·00; while Mr. Giffen's Weighted Mean is ·98.

This consilience might have been predicted by the Calculus of Probabilities, if cotton and perhaps one or two other articles whose values constitute abnormally large weights had been omitted.[2] The fact that even without that omission the results coincide shows an even greater symmetry in the movement of trade than might have been expected.

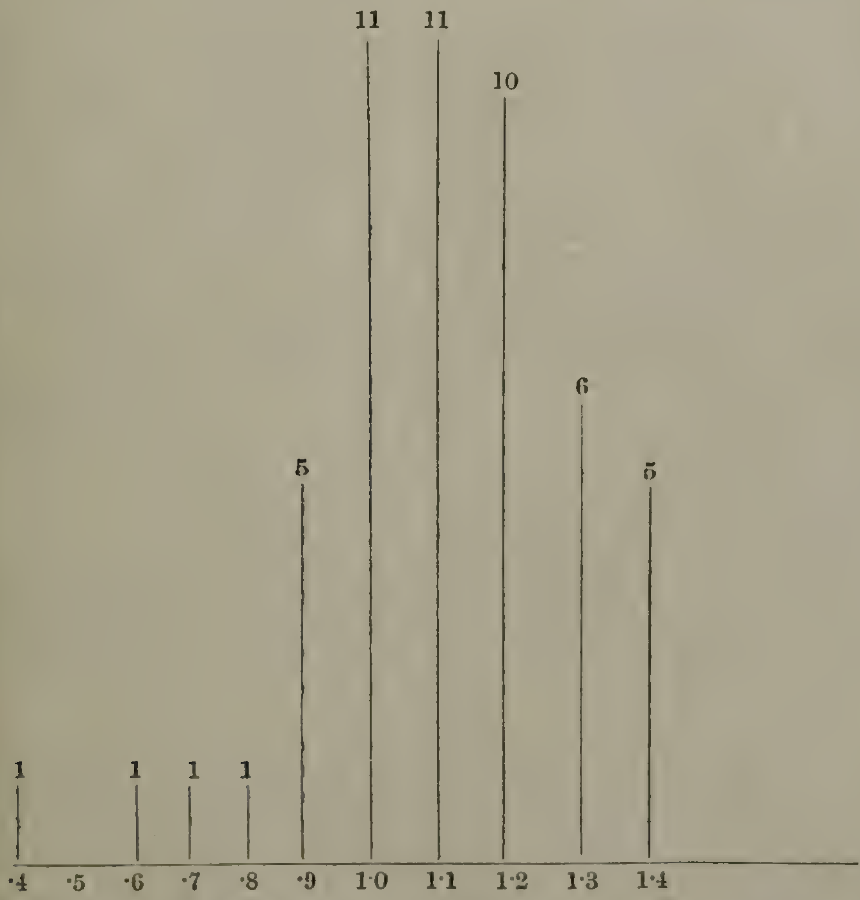
The objection to this plan of taking a simple average between the ratios of quantities is that equal importance is assigned to a growth in the quantity of an insignificant article like valonia and a staple like wheat, of which the quantity imported had in 1875 a pecuniary value some 150 times as great as that of the unimportant dye-stuff instanced. We require, then, a measure of the importance to be attached to different articles of trade. It is assumed that such a measure is afforded by money, or should be, but that the Monetary Standard is itself liable to variation. We require, therefore, to measure the variation of that standard, and thus

[1] 'Reports on Recent Changes in the Value of Foreign Trade, *Parl. Papers*, 1885, c. 4456; and 1888, c. 5386, Part III. table 2.

[2] The verification holds good when one, or more than one, of the returns for *cotton* are omitted.

are brought up against the problem which has been proposed to this Committee.

This problem, as we have seen, presents a variety of phases. But for the particular purpose in hand it will be sufficient to make two divisions. First, we may suppose the variation in the Monetary Standard ascertained by examining a wider sphere of industry than foreign trade, or we may confine ourselves to the statistics of exports and imports. The first alternative has not been entertained by Mr. Giffen in his Reports; and it will be dismissed here as leading back to varieties of our problem which have been already considered. Again, the following distinction may be taken. In combining the comparative prices or ratios between



the prices of each article at two compared epochs we may assign a certain weight to each ratio proportioned to the importance of the corresponding commodity, or else we may suppose a change in the level of prices propagated over a whole zone of trade in such wise that we may take a simple average of the given ratios without attending to the corresponding masses of commodity. For a further enunciation of this hypothesis the reader is referred to the former Memorandum,[1] and to the sixth section of the present one. Of these alternatives Mr. Giffen has adopted the former.

[1] *Brit. Assoc. Report*, 1887, p. 280.

It is submitted that this course commits us to some such hypothesis as the following. If, in order to compare the volume of trade for a series of years, we assign a weight to the price of each article proportioned to the importance of that article, we must regard the relative importance of each article as constant for that series of years. If, then, the relative importance of each article is to be measured by the pecuniary value of the quantity bought or sold, the proportions which the value of each article bears to the value of any other article, or to the total value of all the articles, ought to be pretty constant during the whole series of years. This assumption is strikingly verified by Mr. Giffen's Table II. Again, if the proportionate amount expended on each article is pretty constant from year to year, we may conceive a purchasing public (whether the community in whose interest the computation is being made, or the foreigners with whom they deal) constant as to the nature of their wants [though it may be increasing in numbers in the course of years]. Accordingly the rates of exchange between the different articles ought to be constant. In other words, the ratio between the prices of the different articles ought to be constant during the series of years. This assumption is verified as well as could be expected by Mr. Giffen's Table I. and Table III., A.[1]

The values and prices being constant, it is implied that the proportionate quantities also, the number of tons, or it may be gallons, of each article exported or imported, have a degree of constancy. This proposition also may be verified by glancing at the quantity columns in Mr. Giffen's Table IV., or the same figures in the statistical abstract.

These assumptions as to the steadiness of the course of foreign trade being admitted, a definite interpretation may be assigned to the otherwise vague idea of increase in the volume of exports and imports. Or rather two or three definitions become possible. The primary significance of an increase in the volume of foreign trade is as a measure of the benefit which the community desires from foreign trade.[2] This conception is particularly germane to the case where the articles on which the computation is based are commodities imported for the consumption of the community. 'In some countries,' writes Mr. Giffen, 'the whole imports less the re-exports may be treated as imports for final consumption.' If the imports are materials as distinguished from finished products, still the

[1] There are reasons why Mr. Giffen's table of price variations (Table III., A) should present the appearance of stability in a less degree than his table of proportionate values (Table II.) First, each entry in the former table is obtained by comparing one item with another item, viz., the price of an article in any year with the price of the same article in 1861; whereas each entry in the latter table is obtained by comparing an item (the value of an article) with an *aggregate* (the total value), which of course is apt to be more stable than an item. If the suggestion made below of referring each price to the mean price of the article for adjacent years were adopted this contrast would doubtless be diminished.

[2] The variation in the volume of trade as thus conceived is very similar to Cournot's definition of 'real gain,' or loss, of social revenue (*Recherches sur les Principes Mathématiques de la Théorie des Richesses*, ch. x.; and later redactions). But Cournot, who seems not to have seized the idea of 'final utility,' strains the monetary measuring rod beyond its legitimate application when he propounds his paradox that freeing a commodity from a prohibition results in a loss of real gain to the country which becomes an importer thereof (*Ibid.* Art. 89). For this case implies a change in the *quality* of trade, a diversion of the streams of commodity into new channels with which our methods are unable to deal, through failure of the hypothesis enunciated in the text.

unfinished articles may be taken as more or less perfect representatives of consumable commodities.

The case of exports may be thus fitted to this interpretation. It is to be assumed that, given the steadiness in the course of trade which we have postulated, an increase in the volume of exports normally corresponds to an increase in that of imports. Thus exports afford a measure of the advantage derived from foreign trade of the same sort as that which imports afford.[1]

There is a special difficulty in the case of those articles which are imported like cotton in order to be re-exported at a subsequent stage of manufacture. Take the extreme case, mentioned by Mr. Giffen, of tea, which figures as part of the domestic produce exported from France. The French of course derive some advantage from the handling of this article. But the interest which they have in the tea thus transmitted is not proportioned to the value of the article in the same sense as the value of a genuinely native export measures its importance to the nation.

With regard to this special difficulty, and indeed the whole computation, it is to be remarked that we are concerned—not so much with the absolute volume of trade—as the relative volume in one year as compared with another. The relative volume as already stated may be regarded as a sort of mean of the ratios between the quantity (in tons, gallons, &c.) of each commodity in one year and the corresponding quantity. It is a weighted mean, the weights being the respective values of the commodities.[2] Grant, now, that in the proposed case of tea transhipped from France the weight is exaggerated. Yet, as pointed out by the writer in a former Memorandum, some inaccuracy of the weights is not likely to affect the result much. It is only in the case of the larger values, notably cotton imported into the United Kingdom as the material for future manufacture, that the difficulty is serious. Such items ought no doubt to be placed in a separate category, and considered on their own merits; not merely on account of their inaccuracy, but also on account of their mere magnitude. The domineering pre-eminence of one or two items is fatal to the application of the Calculus of Probabilities which flourishes, so to speak, only in a republic of numerous independent not very unequal constituents.

Implicated with this definition of the volume of trade there is a definite method of measuring the variation in the value of money. This

[1] It may be objected that the volume of trade is *per se*, and apart from hypothesis, an interesting datum, or rather *quæsitum*, as affording the measure of profits accruing to the country, or for some such reason. This remark seems just if the corrections of the Monetary Standard which are made for the purpose of estimating the volume of trade are based upon some principle extraneous to the trade, or at least some other principle than that of assigning to each article an importance proportioned to the value exported or imported. All that is contended here is that the received method of measuring the trade by itself, so to speak, postulates a certain analogy between this species of Index-number and the more general one which is based on national consumption. Indeed, it is partly on account of this analogy that the subject appears to deserve such full treatment here.

[2] In the symbols to be presently introduced the ratios of quantity are of the form

$$\frac{q_{ay}}{q_{ax}},\ \frac{q_{by}}{q_{bx}},\ \&c.$$

The corresponding weights are $q_{ax}\,p_{ax}$, $q_{bx}\,p_{bx}$, &c. Thus the weighted mean is

$$\frac{q_{ay}\,p_{ax} + q_{by}\,p_{bx} + \&c.}{q_{ax}\,p_{ax} + q_{by}\,p_{bx} + \&c.}$$

method is of the same general character as that proposed by the Committee, but more partial and imperfect, as concerned only with a fraction of the national consumption, and that fraction often very indirectly represented.

A slightly different conception of the method may be distinguished by an exhaustive casuistry. The measure of the variation in the value of money, which is afforded by the statistics of foreign trade, may be of the species which was defined in the third section of the former Memorandum. This is a standard, adapted indeed to deferred payments, yet for which the items entering into the Index-number 'are not copied from the statistics of national expenditure, but are selected on some other principle.' It is presumed in virtue of the general sympathetic movement of prices that the change in value of the articles of national consumption is adequately represented by the change of value in certain other articles selected on what may be called a random principle from the whole mass of trade. Whichever of these two slightly distinct views we take, we may perhaps describe the principle of measurement as a *quasi*-consumption standard.

Again, as suggested at the end of the last section, the Index-number based on foreign trade may be regarded as an imperfect Currency Standard of the sort described at the end of last section. It may be, and indeed it has been, asked, What is the use of thus drawing out to an additional degree of tenuity distinctions already somewhat fine-spun? Referring to the first report of the Committee for a general indication of the bearing which the theory of our subject has on its practice, the writer would observe, with especial reference to the first and second sections of this Memorandum, that the principle connected with the name of Professor Foxwell affords a rationale for an Index-number, which is admitted to be of great practical importance—that based on foreign trade. An equally intelligible explanation of received practice is not afforded by all the first principles which different theorists have proposed. The Capital Standard, for instance, could hardly be regarded as the theoretical basis on which Mr. Giffen's work, or Mr. Bourne's, may be rested. This reference to first principles is by no means otiose. It assists in deciding what differences of method are fundamental, how far our choice may be governed by regard for mere elegance and ease, and we may say of rival methods—

'Whate'er is best administered is right.'

Thus it will be maintained that Mr. Bourne's dissent from Mr. Giffen's practice is not justified by first principles. On the other hand, reasons will be given for differing from the opinion which Mr. Giffen seems to entertain, that his second method, set forth in the fourth table of his earlier Reports, is less serviceable than the method to which his first three tables refer.[1]

The discussion of the questions raised may be facilitated by the use of symbols. Let a, b, c, &c., denote the commodities of which we are given the quantities and prices for a series of n years. Let the successive years be designated by the numerals 1, 2, 3, &c. Let q_{a1} be the quantity (imported or exported) of the commodity a in the year 1; q_{b1} the quantity of commodity b in the same year, and so on. And let q_{a2}, q_{b2}, &c., represent the quantities in the year 2, and so on. The absolute magni-

[1] *Parl. Papers*, 1878–9, C. 2247, p. 4, par. 4.

tude of the quantities of commodity increases in general from year to year; but the *proportions* between the respective masses of commodity are, by hypothesis stated at page 142, constant. Thus we are to imagine each set of ratios $q_{a1} : q_{b1}$, $q_{a2} : q_{b2}$, &c., $q_{an} : q_{bn}$, as quantities of the same order hovering about a mean or diverging from a type which we may denote by $\gamma_a : \gamma_b$. Similar suppositions are made with respect to the other articles. The annexed arrangement of the symbols brings these relations clearly under view:—

	Article a	Article b				Article r
Year 1	q_{a1}	q_{b1}	.	.	.	. q_{r1}
Year 2	q_{a2}	q_{b2}	.	.	.	. q_{r2}
.	.					
.	.					
.	.					
Year n	q_{an}	q_{bn}	.	.	.	. q_{rn}
	γ_a	γ_b				γ_r

Here each γ stands for any of the q's in the column above it; or, rather, the ratio of any one γ to another; *e.g.*, $\gamma_a : \gamma_b$ stands for the ratio of the corresponding q's for any year.

Similarly let p_{a1} denote the price of the article a in the year 1, p_{a2} the price of the same article in the year 2, and so on. Here the absolute magnitude of the prices varies from year to year with the appreciation or depreciation of money; but the proportions between the prices of the respective commodities are regarded as fairly constant. Then we have a scheme for the p's like that of the q's:—

	Article a	Article b				Article r
Year 1	p_{a1}	p_{b1}	.	.	.	p_{r1}
Year 2	p_{a2}	p_{b2}	.	.	.	. p_{r2}
.	.					
.	.					
.	.					
Year n	p_{an}	p_{bn}	.	.	.	. p_{rn}
	π_a	π_b				πr

Here each of the π's is typical of the column above it; or, rather, the ratio of any one π to another is typical of the ratio between the corresponding p's for any year.

Upon these hypotheses the following appears to be the most general, or at least a sufficiently general, representation of the proportionate volumes of trade for the series of years.

Volume of imports [or exports] in year x is proportional to value of imports [or exports] in year x ÷ Index-number indicating the ratio of the price-level in the year x to the level of prices which is taken as standard.

∴ Volume of imports [or exports] in year x is proportional to value of imports [or exports] in year x

$$\div \frac{\gamma_a\, p_{ax} + \gamma_b\, p_{bx} + \&c.}{\gamma_a\, \pi_a + \gamma_b\, \pi_b + \&c.},$$

where, as already explained, γ_a, γ_b, &c., π_a, π_b, &c., are the typical quantities and prices.

So far we have supposed both the quantities and prices of the articles imported or exported to be given. In the concrete case where these data are wanting for a considerable set of articles of which the value only is

given, the formula is still the same, viz., Volume in year $x \propto$ Value in year $x \div$ Index-number indicating ratio of the level of prices in the year x to the standard level. The only difference is that we must now base our Index-number upon a part only of the total trade whose volume is required, assuming that what is true of a part is true of the whole.

How now are we to determine the *types* which enter into our formula? First as to the quantities. The most obvious course is to take the q's of a particular year for the typical γ's, *e.g.*, q_{ax} for γ_a, and so on. In the absence of special reasons in favour of or against certain years, we may select any one of the n years to furnish the typical quantities. We have thus at once n different schemes. But it need not be postulated that the same system of quantities should be adopted for each of the series of years. In fact, in the scheme of Mr. Giffen's Table IV. different factors are employed for each comparison, namely, the factors furnished by each year which is being compared in respect of its level of prices with the standard year (1861). If this additional liberty is used to its full extent for every one of the n schemes already enumerated, we have now n variants; that is, in all we have n^2 different formulæ. However, it may be admitted that these additional schemes, with the important exception of the particular one used by Mr. Giffen in his Table IV., are, if not less accurate, at least less elegant than those which were mentioned first. We shall therefore dismiss these variants with the exception of that one which seems peculiarly appropriate. So far, then, we have $(n+1)$ schemes presented by the varieties of the quantity-types, the price-type being supposed fixed.

But the price-types also are manifold. A system of such types is furnished by the actual prices of every year—in the absence of special reasons against some particular year. Thus Mr. Giffen has chosen 1861 as the year of standard prices, Mr. Bourne 1883. We have thus n additional cases, which, compounded with the $(n+1)$ above ground give $n\ (n+1)$ distinct schemes or formulæ for comparing the series of volumes.

Out of this whole number there are $2n$ which deserve particular attention, namely, those in which the quantities or factors employed in each comparison are supplied by one of the compared years. One system of such schemes in number n is obtained by using in every comparison the factors supplied by the year of standard price; in other words, by taking the types of price and quantity from the same years. The other system, also numbering n, is that which was noticed in the last paragraph but one as having been used by Mr. Giffen in his Table IV. The quantities in this system are supplied by the year which is being compared in respect of its level of prices with the year of standard price. Of course, if we were concerned with only one comparison at a time, if each comparison were an independent operation, these selected schemes would be entitled to a decided preference. But where the object is to find a series of numbers, representing by the ratio of any one to any other the proportion between the volumes of trade for the corresponding years, there seems to be no advantage in constructing our measuring-rod with the factors of one year rather than another. The whole computation presupposes some such hypothesis as that which has been enunciated above; and on that hypothesis one year has no claim to be preferred before another.

What may be said in favour of the selected schemes is that they are very slightly more convenient than the other ones. In general, it may be observed that we have n operations, each of a kind illustrated by the for-

mation and addition of the columns in Mr. Giffen's Table III., B. One such operation is required to construct the denominator of the Index-numbers which express the ratio between the level of prices in the standard year and each other year. That denominator is in general terms, as we have seen, $\gamma_a\, \pi_a + \gamma_b\, \pi_b + \&c.$; or, if we take the γ's from one year, say x, and the π's from another year, say y, the denominator becomes

$$q_{ax}\, p_{ay} + q_{bx}\, p_{by} + \&c.$$

To be compared with this denominator there are $(n-1)$ numerators, one for each of the years except the standard one, each numerator of the form

$$q_{ax}\, p_{az} + q_{bx}\, p_{bz} + \&c.,$$

where z is a year compared with y in respect of the level of price.

There are, in general, then, n such operations: $(n-1)$ for the numerators, and one for the denominator. But in the particular case where the types of price and quantity are taken from the same year, where $x = y$, the denominator reduces to

$$q_{ax}\, p_{ax} + q_{bx}\, p_{bx} + \&c. = \text{Value for year } x,$$

a given figure which requires no computation. Accordingly one operation—that of calculating the denominator—is spared. Again, if we take the factors from the particular year, say z, which is being compared in respect of the level of prices with the standard year, that is, if in the last paragraph we put $x = z$, the numerator reduces to

$$q_{az}\, p_{az} + q_{bz}\, p_{bz} + \&c.,$$

forming the total value for the year z, which is a given figure. But meanwhile, in employing a different scheme of factors for each numerator, we have necessitated the use of $(n-1)$ different denominators, each of the form

$$q_{az}\, p_{az} + q_{bz}\, p_{bz} + \&c.$$

The valuation of each of these forms will require $(n-1)$ operations of the kind described.

In addition to this slight advantage in respect of ease there may also be ascribed a peculiar elegance to the selected formulæ. But they have no claim to the highest degree of accuracy. That distinction belongs to a more complicated system, which is now to be described. We have so far taken for granted that each typical quantity γ is furnished by some q which is the actual quantity for a particular year. But it is more agreeable to the Calculus of Probabilities to take some *Mean* of the given q's for the type γ. This principle has been recognised in the First Report of the Committee, where it is proposed that for the purpose of comparing the level of prices at two different epochs the factors employed should be the mean of the respective quantities. In the variety of the problem with which we are at present concerned we may suppose a whole series of corresponding quantities, *e.g.*, for the article a q_{a1}, q_{a2}, &c., q_{an}. The mean of all or any number of these quantities may be taken for our type. Now, out of n quantities (2^n-1) distinct combinations may be formed. Instead, therefore, of the n different arrangements of factors which we at first found we have now 2^n-1; which, being combined with the one peculiar scheme employed in Mr. Giffen's Table IV., makes 2^n.

Similar remarks apply to the types of price. We have so far taken actual prices for our types. But it may be better to imagine a sort of

mean year with normal or typical prices formed by arranging the actual prices of several years. This principle has been employed to some extent by Jevons, Dr. Soetbeer, Mr. Palgrave, and Mr. Sauerbeck. In virtue of this principle the n different bases of price which we found before are swelled to 2^n-1. Altogether, therefore, we have $2^n \times (2^n-1)$ distinct schemes of Index-number.

This account may be further multiplied if we have a choice, as would often be proper, between the Arithmetic Mean and a certain other species of average which is noticed below. However, it may be well to leave some margin for the occurrence of abnormal years (like 1873) whose data cannot be used freely. So let us be content with the modest estimate just furnished, as resulting from that degree of liberty of choice which we have so far contemplated.

That is, however, a very narrow view. For each q which we have employed may be replaced by an expression which is by hypothesis *of the same order*. For instance, we are entitled to put for q_{ay}, q_{by}, &c., the expressions $q_{ay}\frac{p_{ay}}{p_{ax}}$, $q_{by}\frac{p_{by}}{p_{bx}}$, &c.; say q'_{ay}, q'_{by}, &c. This is, in effect, what Mr. Giffen has done in the classical computations comprised in the first three tables of his reports. His formula for the volume of any year, z, may be written in our notation :—

$$\text{Volume of year } z \propto \text{Value of year } z \div \frac{\left(q_{a75}\frac{p_{a75}}{p_{a61}}\right)p_{az} + \left(q_{b75}\frac{p_{b75}}{p_{b61}}\right)p_{bz} + \&c.}{\left(q_{a75}\frac{p_{a75}}{p_{a61}}\right)p_{a61} + \left(q_{b75}\frac{p_{b75}}{p_{b61}}\right)p_{b61} + \&c.}$$

The reader will easily see the equivalence of this formula to that which Mr. Giffen has made familiar, if the symbols p_{a61}, p_{b61}, &c., are brought outside the brackets both in the numerator and denominator. The denominator, for instance, will become $(q_{a75}\,p_{a75}) + (q_{b75}\,p_{b75}) + \&c.$; corresponding to the column headed 1875 in Mr. Giffen's Table II.

By parity it may be shown that the Index-number constructed by Mr. Palgrave implies the following formula for volume :—

$$\text{Volume of year } z \propto \text{Value of year } z \div \frac{\left(q_{az}\frac{p_{az}}{\pi_a}\right)\times p_{az} + \left(q_{bz}\frac{p_{bz}}{\pi_b}\right)p_{bz} + \&c.}{\left(q_{az}\frac{p_{az}}{\pi_a}\right)\times \pi_a + \left(q_{bz}\frac{p_{bz}}{\pi_b}\right)\pi_b + \&c.}$$

where π_a, π_b, &c., are types of price obtained by taking an average over certain years.[1] In fact, Mr. Palgrave's scheme may be regarded as a variant of the plan employed in Mr. Giffen's Table IV., which was above commended to particular attention.

These q''s may be combined with each other in the same way as the q's; and, indeed, the q''s and the q's may be mixed. However, these operations would be laborious and inelegant. We shall, therefore, cull from the infinite field which has just been opened up only just such a number as to double the estimate already reached. It may be useful to show how this additional contingent is reached, taking as a conspicuous instance the materials of Mr. Giffen's work. It was open to him to have taken for the basis of prices some year other than 1861. In fact, in his

[1] See, on Mr. Giffen's and Mr. Palgrave's Index-numbers, sect. ii. of the present writer's first Memorandum, *Brit. Assoc. Rep.*, 1887, p. 265.

fourth table he has so used both 1873 and 1883. Or the base line might have been composed by taking the average prices of each article for several years, after the manner of Mr. Palgrave or Mr. Sauerbeck, except that the years entering into the average need not be consecutive. It may be asked, What reason could there be for taking half-a-dozen years—some at the beginning, it might be, and some in the middle, or at the end, of the period under review? The reason might be the very absence of a reason. Suppose it were thought desirable, in order to avoid accidents, to take a mean of half-a-dozen years, and not worth the trouble of including more than half-a-dozen. In the absence of special objections to certain years any one half-dozen is as good as any other. There are, therefore, as many half-dozens as there are combinations of six to be formed out of the n years. To avoid the suspicion of cookery it might be best to make a selection at random—by spinning a teetotum, or by some equally arbitrary process. It should be observed that the labour of taking averages over several years need not be so formidable as might be supposed, if *Medians* instead of Arithmetic Means be employed. In view of abnormalities like the irregular rise of prices in 1873, there would be a peculiar propriety in the use of the Median.[1]

Exactly similar considerations apply to the factors or proportions which form Mr. Giffen's second table. It was open to him, as he points out, to take these proportions from some other year than 1875. In fact, he tried several years with substantially identical results.[2] There are, therefore, at once as many factors as there are years in the series. Moreover any mean of these factors may be taken. Here, again, then, we have 2^n-1 schemes to choose from.

Well, then, any one of these (2^n-1) measuring-rods may be used in connection with any one of the (2^n-1) price-scales above mentioned. Thus arise $(2^n-1)(2^n-1)$ arrangements for comparing the years in respect of the level of prices. To these may be added Mr. Palgrave's system of factors combined with any one of the (2^n-1) price-scales. This addition swells the contingent to $2^n \times (2^n-1)$. This number is to be added to the previous estimate, viz., $2^n \times (2^n-1)$, which is thereby doubled, becoming $2^{n+1}(2^n-1)$.

The question may now arise, How large is n to be? It may be suggested that it should be as small as possible, namely, 2. We should proceed according to the method recommended by Professor Marshall,[3] and exhibited at length in the former Memorandum.[4] We should compare the present year with last year only, next year with the present, and so on. The fact that Professor Marshall refers to the general problem of a measure based on articles of consumption, whereas we are now particularly concerned with the volume of trade, does not appear to affect the reasons on which his recommendation is based. However, it may be well to combine that principle with the practice of averages over several years. At any rate, the latter procedure is countenanced by the most eminent statisticians. Extending their review over a considerable tract of time, they have, in effect, taken for granted that sort of solidarity between the years which we have all along supposed. Ten years, twenty years, nay, even forty years, have thus been compared *inter se*. Let us take the

[1] See below, Sect. V., and the papers to which reference is there made.

[2] *Parliamentary Papers*, 1878–9, c. 2247.

[3] *Contemporary Review*, March 1887.

[4] *Brit. Assoc. Report*, 1887, p. 269.

period of twenty years as quite permissible; then by the formula above reached we find the total number of available arrangements to be more than a *billion*. All these billion schemes are on the whole about equally good, some having a slight advantage in respect of safety, and others of ease.

SECTION IV.

Mr. Bourne's Method.

These elucidations assist us in discerning the character of a method which was proposed by Mr. Bourne so long ago as 1873, and more recently has been submitted to the British Association together with some criticism of Mr. Giffen's celebrated computations.[1] It will be found that Mr. Bourne has discovered, not *the* method, but only *a* method—a very good method, no doubt, but not much better than many others, not more serviceable than hundreds, not more accurate than millions that are available.

A little attention will show that the reasoning is virtually identical with that which Mr. Giffen employs in his fourth table when he compares the quantities in any year at the prices of that year with the same quantities at the prices of 1883; and goes on, as, for instance, in his first Report, page v, to compare the measure (for the level of prices) so obtained in order to deduce the comparative volume of any year from its value. It is not to be denied, indeed, that this method, under the neat handling of Mr. Bourne, has acquired great elegance. But we must take care not to exaggerate its pre-eminence over other methods.

In the first place it does not seem to have any advantage over the twin-method which was noticed along with it above.[2] This method is, in brief, to take as the measure of changed level of prices

$$\frac{\text{Quantities of 1883 at prices 1887}}{\text{Quantities of 1883 at prices 1883}}.$$

There is no reason to think that this method would be less accurate than its converse. And it would enjoy the distinction of not having been worked out in detail by Mr. Giffen (in his latter tables).

A certain precedence, perhaps, attaches to these twin-methods in virtue of a slight superiority in ease and elegance.[3] But this slight distinction must not be mistaken for a serious difference in worth or power. Nor is Mr. Bourne's position defensible when he disapproves the method set forth in Mr. Giffen's first three tables. The gist of Mr. Bourne's objections is contained in the following passage, of which the context should be studied:—[4]

'The proportions of [quantities of] cotton yarn for 1865, 1875, 1883 stood as 104 : 216 : 265, but by value as 10 : 13 : 14, and the percentages of increase or decrease from the standard of 1861 were as +91·23 : +16·91 [misprinted in the Report 41·63] : −2·3. It is difficult to see how any combination of these factors, so widely differing in their ratios, can bring about the result that the Index-numbers for cotton yarn should be altered as +5·38 : +1·00 : −0·14 as shown in the Board of Trade tables.'

[1] *Brit. Assoc. Report*, 1885 and 1888.
[2] Above, p. 146.
[3] Above, p. 147.
[4] *Brit. Assoc. Report*, 1885, p. 868.

This passage, with its context, presents great difficulties. As Mr. Giffen's 'Index-numbers' do not purport to be measures of volume, but of changed level of prices, there is no reason for surprise that the 'factors' of quantity and value should have no visible effect on the 'result that the Index-numbers for cotton yarn should be altered' by certain additions. The additions to the Index-number are proportional to the percentages of increase or decrease of price ($+5{\cdot}38$, $+1$, $-0{\cdot}14$; proportional to $+91{\cdot}23$, $+16{\cdot}91$, $-2{\cdot}31$), and that is all that is to be expected. It seems as if the original writer had stated the relation between a yard and a metre as a preliminary to comparing the height of an Englishman and Frenchman, the former height having been given in yards, the latter in metres. The critic gives the relative height of the Englishman and Frenchman, and then complains that this factor has no correspondence with the relation between a yard and a metre.

Such appears at first sight to be the drift of the passage above cited. It will be found, however, from the context that the critic has not overlooked the fact that the object of the 'Index-number' in question is, to continue our metaphor, the comparison of the two scales, yard and metre. But he seems under the mistaken impression that this comparison can best be effected by giving the Frenchman's height in metres and also in feet, and comparing these figures. Now, it is here contended that the two scales may equally well be compared by taking the Englishman's height both in metres and feet.[1] Nay, a German will do equally well for the purpose of comparing the two scales of measurement.[2] But, in order to bring out the truth which is here implied, it will be well to employ a metaphor which is more nearly an analogy.

The following apologue may put the whole matter in a clear light. Suppose there were given the increase per cent. in the number of births in a certain district, the increase per cent. in the number of the population, and in the number of persons to a birth (or the inverse birth-rate) for several years. There would, of course, be a visible connection between these figures; and any one set, in particular the proportionate population, could be deduced from the other two. Now, if a statistician had assigned an Index-number purporting to represent the alteration in the numbers of the population, and the alterations so assigned were not deducible from the first and third sets of data, and not coincident with the second, it would, no doubt, be reasonable to complain that it was difficult to see how the given factors brought about that result.

But our problem is by no means so simple. It is like those problems in vital statistics which Laplace, in the absence of a complete census, proposed to solve by the aid of the Calculus of Probabilities. He supposes that the total number of births in a country has been ascertained from registers of baptisms, and that the birth-rate, or its reciprocal, the number of persons to one birth, has been observed at two or more epochs in several districts, which are taken as fairly representative of the whole country. If the birth-rate were constant from year to year, we might reason thus:—

Population in year y : Population in year x :: Total No. of births in y : Total No. of births in x (x being the standard year).

But if the birth-rate is considered as varying between the two epochs

[1] The twin-method alluded to on our page 150. [2] Mr. Giffen's first method.

compared a correction must be made for this circumstance. We have then:—

$$\text{Population in } y \propto \text{population in } x \times \frac{\text{Total No. of births in } y}{\text{Total No. of births in } x} \div \frac{\text{Average birth-rate in } y^{1}}{\text{Average birth-rate in } x}.$$

Now, the last-written fraction may on certain suppositions be determined by taking a measure of the variations in birth-rate (at one epoch compared with another) in each of the observed districts, with due attention to the varying size of the districts, the different importance (for the purpose in hand) of these rates. In other words, if the districts are named a, b, &c., we may write

$$\frac{\text{Average birth-rate in } y}{\text{Average birth-rate in } x}$$

$$= \frac{\text{Population of } a \text{ in } y \times \text{birth-rate of } a \text{ in } y + \text{population of } b \text{ in } y \times \text{birth-rate of } b \text{ in } y + \&c.}{\text{Population of } a \text{ in } y \times \text{birth-rate of } a \text{ in } x + \text{population of } b \text{ in } y \times \text{birth-rate of } b \text{ in } x + \&c.}$$

This is the analogue of Mr. Bourne's method, in which it will be seen that *there is postulated a certain constancy in the proportions between the population of each district to that of the others and of the whole country.*

Suppose a writer had employed the proportions furnished by the year 1883 in order to determine the relation between the birth-rate of that year and of the year 1865.[2] He, in effect, postulates the constancy of proportions (between the different districts and the whole country) to prevail over that period. It is not open, then, to him to complain of another writer who employs the proportions furnished by the year 1875 in order to compare the population for a series of years between 1865 and 1883. But, if the use of those proportions is admissible, then the sort of verification which the writer of the vexed passage under review appears to expect was not to be expected.

In short, given the hypothesis which has been hinted metaphorically here, and stated explicitly above, the method which Mr. Bourne has propounded has no great advantage over the other methods. That hypothesis not being given, Mr. Bourne's method, equally with the others, falls. Of the varied ramifications of the problem he has occupied a particular, and no doubt an eminent, branch. He cannot hope that this particular branch should stand when the others have fallen. One can only bring them down by striking at the root of the whole reasoning.

From this class of methods we shall now proceed to a substitute for them, which has recently been proposed by Sir Rawson Rawson.

Section V.

Sir Rawson Rawson's Method.

Sir Rawson Rawson's original method may be contemplated under two aspects, according as the primary object is to measure variations in the volume of trade or—our peculiar care—in the value of the monetary

[1] Compare the general formulæ given above, p. 145.
[2] Cf. *Brit. Assoc. Rep.* 1885, p. 865 *et seq.*

standard. Sir Rawson's solution of the problem in its former phase is simple: to put the tonnage of 'ships cleared or entered with cargoes'[1] as representing the volume of exports and imports.

Now, we have seen above that volume of trade must be understood in some such sense as equivalent, or rather proportional, to volume of value estimated in a corrected monetary standard, or, if the expression is not too harsh, volume of utility as measured by money. Therefore, in order that the new method should be available for the comparison of volumes in different years, say x and y, the following equation ought to hold approximately:—

$$\frac{\text{Tonnage in year } y}{\text{Tonnage in year } x}=\frac{\text{Corrected value in year } y}{\text{Corrected value in year } x},$$

where 'corrected value' is used as a short title for the figure which is obtained by reducing the total value for each year to a standard or normal level. In other words,

$$\frac{\text{Tonnage in year } y}{\text{Tonnage in year } x}$$

$$=\frac{\text{Quantity of } a \text{ in } y \times \text{normal price of } a + \text{quantity of } b \text{ in } y \times \text{normal price of } b + \text{\&c.}}{\text{Quantity of } a \text{ in } x \times \text{normal price of } a + \text{quantity of } b \text{ in } x \times \text{normal price of } b + \text{\&c.}}$$

Now, 'tonnage' is the measure of a ship's capacity for cargo. Tonnage is, or is proportioned to, the cubical capacity of that part of a ship which is available for cargo.[2] Accordingly the first step towards esta-

[1] Given in the *Statistical Abstract.*

[2] Accordingly Sir Rawson Rawson's priority is not affected by Drobisch's suggestion (noticed in the former Memorandum) to put the number of tons or hundredweights in the total mass of commodities as the measure of their volume. *Mutatis mutandis*, the tests here applied to Sir Rawson's method are applicable to that of Drobisch. The validity of the latter is confirmed by the statistics of the German foreign trade for 1885 and 1886, which have recently been published by the Board of Trade, along with an estimate of the change in volume between 1885 and 1886, based upon the method employed in Mr. Giffen's Table IV. (*Parl. Papers*, 1888, c. 5597). The 'quantities' of the German exports and imports are all expressed in (German) tons, so that Drobisch's method is readily applicable. The following tables exhibit the results of that method in contrast with the theoretically more perfect computation. The results are expressed as Index-numbers for the volume and the level of prices in 1886 as compared with 1885. The imports and exports of the precious metals have not been included in the data:—

German Imports of 1886 comparative with those of 1885	Drobisch's Method	Mr. Giffen's Method
Index-number for Volume	·95	·98
Index-number for Price-level . . .	1·03	·99

German Exports of 1886 comparative with those of 1885	Drobisch's Method	Mr. Giffen's Method
Index-number for Volume	1·01	1·04
Index-number for Price-level . . .	1·04	·976

This complete consilience affords an indirect verification of Sir Rawson Rawson's

blishing the relation above stated is to show that the capacity for cargo bears from year to year a constant ratio to the space actually occupied by cargo. In other words, we require to be assured that an average ship (entering or clearing with cargo) is as fully loaded in one year as another. Sir Rawson Rawson, whose sagacity and candour have anticipated every objection, is satisfied that we may dismiss this scruple.

We may therefore write the postulated equation:—

$$\frac{\text{Bulk of } a \text{ in } y + \text{bulk of } b \text{ in } y + \text{\&c.}}{\text{Bulk of } a \text{ in } x + \text{bulk of } b \text{ in } x + \text{\&c.}}$$

$$= \frac{\text{Quantity of } a \text{ in } y \times \text{normal price of } a + \text{\&c.}}{\text{Quantity of } a \text{ in } x \times \text{normal price of } a + \text{\&c.}}$$

where 'bulk of a in y' is short for the total space, the volume in cubic yards, occupied by the whole mass of commodity a which is exported, or as the case may be imported, in the course of the year y. The relation of these two fractions may be better seen by putting each of them in the form of what may be called a 'weighted mean' of the ratios of bulk; (or, as implied in the last note, we might take as the ratios to be operated on: $\frac{\text{Quantity (in tons or gallons) of } a \text{ in } y}{\text{Quantity of } a \text{ in } x}$, &c.). To effect this in the left-hand member of the equation, we should leave the denominator as it is, and we should alter each term of the numerator thus: For Bulk of a in y write Bulk of a in $x \times \frac{\text{Bulk of } a \text{ in } y}{\text{Bulk of } a \text{ in } x}$, and so on. The left-hand side of the equation is now in the form of a weighted mean of the ratios, $\frac{\text{Bulk of } a \text{ in } y}{\text{Bulk of } a \text{ in } x}$, &c., the weights being bulk of a in x, bulk of b in x, &c. Treating the right-hand member in the same spirit, we obtain a weighted mean of the same ratios, each weight being of the form, bulk of a in $x \times$ No. of tons [gallons, pieces, &c.] in unit of bulk $\times$ normal price of ton [gallon, piece, &c.], or, as it may be more shortly written, value of Bulk of a in x at standard prices—that is, assuming that the number of tons, &c., in a unit of bulk is constant from year to year. But if this cannot be assumed we must add a remainder, of which the numerator is made up of terms like the following:—

Bulk of a in y (No. of tons in unit bulk of a in y—No. of tons in unit bulk of a in x) $\times$ normal price of a; and the denominator is the total value in x.

Omitting this remainder for the present we have now to compare two weighted means of the same set of quantities (the ratios above specified), the weights being in the one expression each of the form, bulk of a in x;

method, in so far as it is on the same footing with Drobisch's; each admitting of being regarded as an arbitrarily weighted mean of certain ratios, such as

$$\frac{\text{tons of commodity } a \text{ in 1886}}{\text{tons of same commodity in 1885}}$$

(the ratios of quantity described at p. 140 above). Whereas the theoretically correct expression is the value of commodity a at normal (or corrected) prices; Drobisch puts tons avoirdupois of a, and Sir Rawson Rawson puts (in effect) tonnage (or cubical volume) of a.

From this point of view it will appear that both methods derive confirmation from the experiment tried above, at p. 140, of taking an altogether unweighted mean of the ratios between quantities.

in the other expression of the form, value of a in x. Now, it has been shown by the present writer in a memorandum on the Accuracy of Index-numbers, published in the Report of the British Association for 1888, that, in forming a mean of any given set of quantities, the difference between the results obtained by adopting different systems of weights is apt to be inconsiderable. This proposition has been established both by reasoning from the theory of probabilities and by pretty copious examples. It is shown that the divergence between the two results tends to diminish as the number of (supposed independent) items entering into the average increases; the probable deviation being proportioned to the inverse square root of the number of items. This tendency to evanescence is resisted by three circumstances: the inequality of the given items which are to be averaged, the inequality of the weights which constitute the set or system which is regarded as true, and the largeness of the difference between each weight in that one system and the corresponding weight in the other system. It can be shown that the last two circumstances are equivalent to, or, rather, are contained under, one attribute, namely, the inequality of the weights in either system.[1]

These criteria are now to be applied to the case before us. In the first place we have a very large number of elements to deal with—much larger than the number of enumerated articles which enter into Mr. Giffen's Index-numbers. For Sir Rawson Rawson's Index-number includes the unenumerated as well as the specified articles. There is, therefore, a strong *primâ facie* presumption that the divergence between the two compared expressions will prove to be unimportant; even smaller than in the case of the Index-numbers compared in the paper referred to, the number of items being larger here than there.

Then, as to the counter tendencies. There is no reason to apprehend any fatal inequality in the ratios of the form $\frac{\text{Bulk of } a \text{ in } y}{\text{Bulk of } a \text{ in } x}$. At least it would only be in cases of articles where the bulks were very small that such an influence need be apprehended, the ratio in such a case tending to infinity. It is easy to see, however, that this tendency would be corrected by the 'weights'; that such an article would not be likely to have much effect on the whole expression. There seems no reason to apprehend any much more marked inequality in comparative bulks than in comparative quantities, which, as we know from Mr. Giffen's tables, are not fatally unequal.

There remains the twofold condition that the weights of either system should not *inter se* be very unequal. The most serious violation of this condition seems to be coal in the case of exports. It appears from Sir Rawson Rawson's statistics that the bulk of coal takes up an inordinate proportion of the total bulk of all commodities. Accordingly he has very properly excluded coal from his Index-number. It is interesting to observe that, as shown in Tables I. and VII., the inclusion of coal does not, as a matter of fact, distort the result so much as might have been

[1] The measure of 'inequality' is the square root of the sum of squares of all the weights in a system ÷ their sum. The divergence between the results is directly proportionate to this expression. If the weights are perfectly equal the factor reduces to *unity* $\div \sqrt{n}$. But suppose one weight preponderates over its fellows to such an extent as to constitute half of the total mass, the remainder of which we may imagine split up among a number of small weights; the resulting expression is no longer of the order $1 \div \sqrt{n}$, but equals, at least, $\frac{1}{2}$.

expected, or indeed in any considerable degree. The tables referred to should be compared with the Appendix at p. 159, as strikingly illustrating how different principles of averaging bring out the same mean result; in short, that in our sort of work it is not very easy to go wrong.

Among imports, grain and timber are suspicious. But with regard to timber Sir Rawson Rawson shows that, though the 'weight' (determined by its bulk) is large, yet it is not materially different from what it ought to be as determined by value. However, he is no doubt judicious in excluding such-like items from his final Index-number.

With regard to the inequality of *values*, as this has not proved fatal to Mr. Giffen's and the cognate methods, there is *à fortiori* less reason to apprehend it in the case of an argument which is based on a greater number of independent items. However, it might be well to examine specially the influence of cotton.

There remains to be considered the remainder, which is made up of differences between the density of packing in different years. It is natural to suppose that these should compensate each other except so far as in the course of years a general tendency to increased economy of room makes itself felt. Sir Rawson Rawson sets off against this tendency the increase of passenger traffic; a quantity which he has abundantly shown to be of an order which may be neglected. For short periods, at any rate, the new method appears to constitute an important adjunct to, if not a complete substitute for, the received methods.

Sir Rawson Rawson's method may be regarded in another aspect as affording a measure of the level of prices in different years. If the hypotheses made in the earlier part of this paper are conceded, no additional remark is called for here. We have simply to write Index-number for level of prices in year y as compared with $x =$ average price in y $\div$ average price in $x = \dfrac{\text{Value in } y}{\text{Volume in } y} \div \dfrac{\text{Value in } x}{\text{Volume in } x}$, $\left(\text{or } \dfrac{\text{Value in } y}{\text{Value in } x} \div \dfrac{\text{Volume in } y}{\text{Volume in } x}\right)$; where the values are given figures and the volumes are proportioned to the respective tonnages. We thus obtain a new and remarkably easy solution of our problem.

Section VI.

The present Writer's Method.

We have so far been supposing that the importance attached to each variation in price is, or ought to be, proportioned to the value of the corresponding article. But we have now to entertain a different supposition and distinct method. We are now to imagine a general change coming over the monetary world—or some zone of it like wholesale prices—like a general variation in temperature or atmospheric pressure over a physical region which is not perfectly level and uniform in its conditions. In reading a barometer or thermometer in any particular place with a view of ascertaining the fact and amount of a general change it would not be appropriate to attach importance to the mere size of the tube and quantity of the rising or falling liquid. In fact the *smaller* thermometer has so far the preference, as it takes on more quickly changes of temperature in the surrounding medium. Sensitiveness, not size, is the criterion of these indicators. So also, in virtue of

well-known analogies between the unity of price in the same market and the equilibrium of fluids in the same vessel, the change of price in a large market is not more indicative of the sought mean variation than a change of price in a small market. *Primâ facie*, for the purpose in hand, each observation should count for one. Or, if more weight attaches to a change of price in one article rather than another, it is not on account of the importance of that article to the consumer or to the shopkeeper, but on account of its importance to the calculator of probabilities, as affording an observation which is peculiarly likely to be correct—peculiarly likely to coincide with that *type* which he is seeking to elicit.

This type of mean variation may be generally defined as that figure which would be presented most frequently if we were to continue indefinitely the long series of price-ratios, or at least that return in whose neighbourhood the greatest number of these statistics cluster. It is, in other words, the Greatest Ordinate of the complete curve, or the highest column of the rectilinear diagram, which represents by its abscissa ratio between the prices of two compared epochs, and by its ordinate the frequency with which that ratio would be returned if the statistics were extended over every region of industry which is subject to independent fluctuations. It is even allowable to imagine series of statistics still longer,[1] namely, those which would ideally occur if we could go on and on multiplying observations under unchanged conditions. As Dr. Venn says :—

'We say that a certain proportion begins to prevail among the events in the long run ; but then, on looking closer at the facts, we find that we have to express ourselves hypothetically, and to say that, if present circumstances remain as they are, the long run will show its characteristics without disturbance.'

The grounds for thus defining our *quæsitum* were stated in that part of the former paper which referred to semi-objective averages or types. A reference should be added to the sections on the Greatest Ordinate in Dr. Venn's 'Logic of Chance.'[2] Compare also the following weighty words in the masterly study on 'Cambridge Anthropometry' which he has recently contributed to the Anthropological Institute: 'The ordinary mean here is obviously an imperfect guide. . . . What we ought to do, owing to the obvious asymmetry of the curve of frequency, is to take, not the arithmetic mean, but what is called "the point of maximum frequency," as this is a far truer index of what may be considered the normal length of vision.' Dr. Venn is discussing a problem analogous to ours, namely, how to extricate from an *unsymmetrical* group of observations that mean value which may be taken as a representative type.

Such being the question, it might seem appropriate to put as answer that return which occurs most frequently in the statistics actually given. But it must ever be remembered, though it is often forgotten by statisticians, that the statistics of prices with which we have to do are of the nature of *samples* : specimens taken at random from a much larger, if not an indefinitely large series. In interpreting these evidences, in inferring the type from a limited number of individuals, we must be guided by the methodical rules which the Calculus of Probabilities prescribes. The theory of errors of observation is here as high above ordinary induction

[1] Compare Dr. Venn, *Logic of Chance*, chap. i. § 14.

[2] The third edition of this unique work, especially the first two chapters and the last two chapters, should be studied by all who wish to contemplate that phase of our problem which is now under consideration.

as in the general field of modern science the received inductive methods transcend the simple enumeration of the ancients. Now, the Calculus of Probabilities teaches that the best answer to our question will not be obtained by taking that which on the face of the evidence seems to be manifested.[1]

The need of this caution is illustrated by the annexed statistics. Looking at these three groups of statistics you might conclude that the first one, designated A, emanated from and, if prolonged, would converge to 30, as that number is the one most frequently repeated. It might similarly be inferred that B in the same sense represents 38. With regard to C, there might be more hesitation, since no one place or figure preponderates. If, however, we double the size of our compartments and consider which is the fullest of these enlarged places, that distinction will be found to belong to 57–58. Accordingly 57·5 might seem the type represented by this group.

But in fact all these groups appertain to the same series, each figure in all of them being formed in the same way, namely, by the addition of ten digits taken at random from mathematical tables. If this series were indefinitely prolonged the figure most frequently repeated would be 45, a figure which in two of the groups does not even occur once. A much better approximation to the greatest ordinate of the complete series is obtained by taking an average other than the greatest ordinate of each set of samples. For instance, the *median*—or figure which has as many of the given observations above it as below it—is for A 42, that being the fourteenth figure in the group of twenty-seven. Similarly the median of B is 44; of C 50. The median of the whole set, numbering eighty-one, is 45; whereas the greatest ordinate is *primâ facie* 38, or perhaps 57·5.[2]

[1] Well does Dr. Venn say in the context of the passage cited from his *Cambridge Anthropometry*: 'Any successful appeal to this [the point of maximum frequency] requires far more extended statistics than those at our disposal.' Yet he has 520 returns before him!

[2] See *Journal Royal Statistical Society*, June 1888, where it is attempted to meet the difficulty presented by such ambiguity. The method there recommended is to rearrange the statistics in larger groups defined by a new 'degree' or 'unit' which is some multiple of the given one (that is, of unity in our example). The unit to be adopted is the *smallest* interval which will bring out the one-headed character of the curve; in the cases above instanced generally 6 or 7. Now, we may begin this operation not only from either extremity of the given discontinuous curve (as stated in the paper referred to), but also with equal plausibility from any intermediate point. There are thus about as many systems as the new degree is greater than the old one; in the cases before us usually six or seven. The apex of *any* of these arrangements giving an equally plausible solution, it is proper to take the Mean of them all. I have performed this operation on each batch of twenty-seven figures (given in the text), and on the united eighty-one, with results in each case differing very little from the Arithmetic Mean, which is the best answer that can be extracted from these data.

Professor Unwin, to whom this problem has been submitted, recommends forming a derived curve by joining the tops of each pair of adjacent ordinates in the given discontinuous curve; and continuing this process of graphical derivation until we reach a smooth (one-headed) curve. He has been so kind as to subject to this treatment the eighty-one figures above given, and after *eight* repetitions of the process finds for the eighth derived curve one whose greatest ordinate is 43—a very respectable approximation, when we consider that what may be called the real point is 45; that the result given by the Arithmetic Mean, which is here the best solution, is 45·2; and that the probable error to which even that best solution is liable is 1·4.

These processes are, however, very troublesome. Still, in doubtful cases, it may be well to check the Median by recurring to first principles and ascertaining the whereabouts at least of the Greatest Ordinate.

A	27	30 31 32 33 34	36 37	40 41 42 43	46 47 48 49	50 51 52	59	64
		30		41 42	46	52		
		30						
B	29	31 32 33 34	36 38 39	41 43 44	45 46 49	50 52 53	56 57 59	62
			38		45 46			
			38		45			
			38					
C			38	40 41 42 44	46 47 49	50 51 52 54	57 58	61
				40 41 44	46	50	57 58	
				40		50	57 58	

It appears, then, that, though our end is the greatest ordinate of the complete series, the best *mean*—if we may be excused a pun which it is not easy to avoid—is not necessarily the greatest ordinate of the sample group. The position of greatest frequency is an object, like happiness, best reached by not aiming at it too directly.

The indirect and ancillary average need not be the one which we have taken for the sake of illustration in the last paragraph. In fact, in the case there instanced the arithmetic mean would be the preferable method. But in the case of prices there is reason to believe that the median is peculiarly appropriate. The nature and varieties of this mean have been fully discussed by the present writer both in his former Memorandum on the same subject as the present one, and also in the Memorandum of 1888 On the Accuracy of Index-numbers.

However, it may not be out of place here to give an additional example taken from the statistics of exports. In the annexed table each figure in the first column (on the left hand) expresses a proportion between the price of an article in 1887 and the price of the same article in 1883. Thus, the price of gunpowder per lb. being in 1887 6·46*d.* and in 1883 5·83*d.*, we have the proportion, or comparative price, $111 = 100 \times 6{\cdot}46 \div 5{\cdot}83$.

Opposite each comparative price are written in the second column or space the values of the corresponding articles for 1887, the proportionate values or actual values divided by a certain figure which is the same for all the entries, viz., 240,000. For instance, the value of gunpowder is 1, being, in round numbers, its actual value 260,000 divided by 240,000. With the reason for adopting this divisor we are not here concerned. Any other basis would serve our purpose as well. It often happens that the same proportion of price is enjoyed by two articles. Thus the comparative price 127 appertains both to arms (fire) and to silk, of which articles the proportionate values are respectively 1 and 6. Accordingly against the entry 127 are written (it does not matter in what order) the figures 1 and 6. Both the prices and the proportions of value are taken from the table given by Mr. Bourne in the paper on Index-numbers contributed by him to the Report of the British Association for 1888.

Well, then, the simple or unweighted median is thus found. There being in all 64 proportions (some of them coincident), we are to select that one which has as many returns above it as below; in short, a point between the thirty-second and thirty-third in the order of magnitude. This is easily effected by counting up the numbers of the 'proportionate values' in the right-hand space. The thirty-second and thirty-third,

counting from the highest, are 12 and 4, both corresponding to the ratio 89. The simple median is thus 89.

127	1, 6
113	4
112	2
111	1
110	
109	
108	1
107	
106	
105	
104	2, 41
103	
102	2
101	17
100	2,[1] 1, 2
99	
98	2
97	
96	7, 7, 4
95	1
94	0, 6, 1
93	
92	7, 5
91	11
90	42, 2, 5, 3, 3,[2] 7
89	47, 12, 4
88	79, 4
87	137, 16, 2
86	5
85	17
84	4, 1
83	29
82	3
81	1, 6
80	1
79	3
78	8, 1, 6, 3
77	11,[2] 20
76	1
75	
74	
73	19
72	
71	
70	1, 5, 9,[2] 2, 3
69	
68	
67	4
66	5
62	2

It was pointed out in the former Memorandum that there is a plausible hypothesis on which, even for the present purpose, it is proper to attach some importance to the values of the commodities, though not necessarily that degree of importance which is prescribed for the standard based on national consumption. The simplest method of attaching importance to the values is to take the simple median of the ratios on the supposition that each of them occurs as often as the number which indicates the corresponding value, or the sum of such numbers where there are more than one of them. Upon this understanding there are in all 666 constructive observations—as near as may be, half above and half below 88. That figure then is the weighted median.

It is pretty certain that this complex median assigns too much importance to the values. And it is probable that the simple median assigns too little. Accordingly a good solution is afforded by combining or comparing the two results, in the example before us taking 88·5 for the answer. Should the two results be markedly different, inquiry may be made as to the cause of the difference, and a preference should be given in general to the simpler combination.

A more elaborate method of weighting the median by taking the square roots of the values was recommended in the former Memorandum. But on second thoughts it appears that the special advantages which this plan may confer hardly compensate for the additional trouble which it involves.

[1] Comparative price of *stockings* per dozen; not explicitly given by Mr. Bourne but inferrible from the entries in his *value* and *volume* columns.

[2] Not explicitly given by Mr. Bourne, but inferrible from his data.

For further illustrations and suggestions the reader is referred to the writer's paper, On some new Methods of ascertaining Variation in general Prices, in the 'Journal' of the Royal Statistical Society for June 1888. It is hoped that the familiarity of the arithmetic mean will not prevent statisticians from attending to the reasons for preferring in certain circumstances the Median.

SECTION VII.

Ricardo's Method.

Ricardo suggests a method of measuring variation in the value of money, when he lays down that a commodity 'which at all times requires the same sacrifice of toil and labour to produce it' is invariable in value.[1] From this point of view the Labour Standard is to be regarded as independent and substantive, not subsidiary to the 'Consumption' (or any other) Standard, as represented in the first report of the Committee. The Labour Standard thus conceived and the Consumption Standard are to each other as 'value' and 'riches' in Ricardo's terminology. 'The labour of a million of men in manufactures will always produce the same value, but will not always produce the same riches . . . . A million of men may produce double or treble the amount of riches of "necessaries, conveniences, and amusements," in one state of society that they could produce in another, but they will not on that account add anything to value.'[2] The Consumption Standard measures the change of money with respect to 'riches'; the Labour Standard with respect to 'real value.' The former relates to the utility of consumption; the latter to the disutility of toil.

Ricardo only proposes the idea of an invariable commodity, of which 'we have no knowledge, but may hypothetically argue and speak[3] about it as if we had.' He does not assist us to ascertain the change in the pecuniary worth of that hypothetical commodity. A more definite scheme is suggested by the remarkable passage of Professor Marshall's evidence before the Royal Commission on Gold and Silver, where he says, speaking of appreciation of gold: 'When it is used as denoting a rise in the real value of gold, I then regard it as measured by the diminution in the power which gold has of purchasing labour of all kinds—that is, not only manual labour, but the labour of business men and all others engaged in industry of any kind.'

It may be remarked on this that the Labour Standard and the Consumption Standard present a certain analogy, the former standing in much the same relation to the fundamental laws of Supply as the latter to those of Demand. As before we posited as normal certain quantities of purchasable commodities, and compared the pecuniary worth at different epochs of that constant sum of commodities; so now we should posit certain amounts of work of various sorts, and compare the pecuniary wages required at different epochs for the same quantity of work. Or, in other words, we should form the ratio of 'new' to 'old' rate of wages in each department of industry, and take the mean of this set

[1] *Principles*, iii. Chapter XX. (On Value and Riches). [2] *Ibid.*

[3] 'And,' he adds, in the exclusive spirit which has characterised almost every propounder of an original method, 'may improve our knowledge of the science, by showing distinctly the absolute inapplicability of all the standards which have been hitherto adopted.'

of ratios, each *weighted* by the amount usually paid in the corresponding department.

Moreover, since upon Ricardian principles the value in exchange of commodities is proportioned to the 'comparative quantity of labour expended on each,' there may be expected some correspondence between the two expressions, not only as to their general form, but also as to the constants which they involve, the *weights* with which the variations of wages and prices are respectively to be affected. But the idea of such a correspondence is marred by the fact that the denominations of finished products do not coincide with the classification of wages. Also the suggested analogy is vitiated by a circumstance which is of great theoretical importance: that values in exchange—and accordingly the proportions which form the weights of the Consumption Standard—depend not only on quantity of labour, but also on interest, according to the different degrees of durability of the capital employed in producing them. This circumstance, as it creates a difficulty [1] with regard to Ricardo's first principles, so it suggests a scruple about the method which is here connected with those principles. When we 'hypothetically argue and speak' of an invariable commodity 'which at all times requires the same sacrifice of toil and labour to produce it,' [2] should we include in the idea of 'sacrifice' not only bodily and mental labour, but also *abstinence*? Shall we introduce into our Index-number the variation in the rate of Interest, weighted by the total amount paid in the way of Interest? Or shall we follow the example of the great theorist himself, and omit the consideration of Interest as often as convenience and rotundity of statement and the purpose of a rough approximation may require? The management of these and other difficulties connected with the Labour Standard must be resigned to the abler hand which has already touched this part of the subject.

Conclusion.

In conclusion it may be useful to enumerate and summarily characterise the principal definitions of the problem, or 'Standards,' [3] which have been discussed in this and the preceding Memorandum. An alphabetical order will be adopted, the order of merit being not only invidious, but also impossible in so far as different methods are the best for different purposes.

1. The *Capital Standard* takes for the measure of appreciation or depreciation the change in the monetary value of a certain set of articles. This set of articles consists of all purchasable things in exsitence in the community, either at the earlier epoch or at the later epoch, or some mean between those sets. This standard is due to Professor Nicholson. It is stated by him (in terms a little less general than those here adopted)

[1] Cf. Sidgwick, *Pol. Econ.* Book I. ch. ii. 'It is rather a perplexing question how Ricardo and M'Culloch could deliberately adhere to the statements above quoted [that labour is the measure of the real value of things, &c.], while they at the same time drew attention to the differences in the value of different products, due to the different degrees of durability of the capital employed in producing them.'

[2] Ricardo, *loc. cit.*

[3] The methods discussed in connection with the names of Mr. Giffen, Mr. Bourne, and Sir Rawson Rawson are rather solutions than statements of the problem.

in his book on *Money*. It is discussed in the sixth and the tenth sections of the former Memorandum.

2. The *Consumption Standard* takes for the measure of appreciation or depreciation the change in the monetary value on a certain set of articles. This set of articles consists of all the commodities consumed yearly by the community either at the earlier or the later epoch, or some mean between those two sets. This standard has been recommended by many eminent writers, in particular by Professor Marshall in the 'Contemporary Review' of 1887. It is proposed by the Committee as the principal standard. It is discussed in the second section of the former Memorandum.

3. The *Currency Standard* takes as the measure of appreciation or depreciation the change in the monetary value which changes hands in a certain set of sales. These sales comprise all the commodities bought and sold yearly at the earlier epoch or at the later epoch, or some mean between those quantities. This standard appears to be implicit in much that has been written on the subject, but to have been most clearly stated by Professor Foxwell. It is discussed in the second section of this Memorandum.

4. The *Income Standard* takes as the measure of the appreciation or depreciation the change in the monetary value of the average consumption, or in the income per head, of the community. This standard is proposed in the fourth and fifth sections of the former Memorandum.

5. The *Indefinite Standard* takes as the measure of appreciation or depreciation a simple unweighted average of the ratios formed by dividing the price of each commodity at the later period by the price of the same commodity at the earlier period. The average employed may be the Arithmetic Mean used by Soetbeer and many others, or the Geometric Mean used by Jevons, or the Median recommended by the present writer. This standard is recommended by the practice of Jevons [1] and the theory of Cournot.[2] It is discussed in the eighth and ninth sections of the former Memorandum, and the fifth section of the present one.

[1] Most of Jevons' celebrated calculations (*Currency and Finance*, II., III., and IV.)., and in particular his calculation of the Probable Error incident to his result (*Ibid.*, p. 157), involve this conception.

[2] Cournot has considered our problem in each of the five volumes in which he has treated of, or touched on, Political Economy (*Dictionary of Political Economy*, Art. Cournot). It is sufficient here to refer to the first and the last of those works, the *Recherches* of 1838 and the *Revue Sommaire* of 1876—the Alpha and almost the Omega of economic wisdom. From these it is clear that variation in the 'absolute' or 'intrinsic' value of money, in Cournot's view, corresponds to the 'Indefinite Standard' as defined in Section viii. of the predecessor to this Memorandum. Cournot illustrates the variation due to a change on the part of money, by that change in the position of the earth with respect to the stars, which is due to the motion of the earth. In this analogy the stars are treated as 'points' (*Recherches*, Art. 9). No account is taken of their mass. The context shows that Cournot contemplates a simple average of distances between the earth and each star; not a *weighted* average, or the distance between the earth and the *centre of gravity* of the stars. In his later works he expressly declares against, or at least thinks unbefitting highest place, the measure of what he calls the 'power of money' (*Revue Sommaire*, Sect. 3), that is, in our terms, the Consumption Standard; the analogy of which is the distance of the earth from the *centre of gravity* of the stars, or rather of certain select stars—say those which are nearest to our human sphere. The Currency Standard, of which the analogy is the distance of the earth from the *centre of gravity* of all stars whatever, does not seem to have been entertained by Cournot.

Cournot, alluding to Jevons' treatment of the problem in *Money*, not unjustly takes him to task for not having distinguished 'assez nettement' variations in the 'intrinsic

6. The *Production Standard* is a designation which may be applied to a method which is related to the Currency Standard very nearly as the Income Standard is related to that based on Consumption. The Production Standard takes as the measure of appreciation or depreciation the change in the monetary value *per head* of the total amount of things produced in the community yearly. This standard is proposed by Professor Simon Newcomb in his 'Political Economy.' It is discussed in the first section of this Memorandum.

7. The *Wages* (and *Interest?*) *Standard* takes as the measure of appreciation or depreciation the change in the pecuniary remuneration of a certain set of services, namely, all (or the principal) which are rendered in the course of production, throughout the community, during a year, either at the initial or the final epoch; or some expression intermediate between the two specified. The theoretical basis and practical construction of such a standard are indicated in Ricardo's 'Principles of Political Economy' (ch. xx. and elsewhere), in Professor Marshall's evidence before the Gold and Silver Commission ('Parliamentary Papers' 1888, C. 5,512, Question 9,625), and in the papers contributed by Mr. Giffen to the second volume of the bulletin of the International Statistical Institute. The standard is discussed in the last section of this Memorandum.

Report of the Committee, consisting of Mr. S. Bourne, Professor F. Y. Edgeworth (*Secretary*), Professor H. S. Foxwell, Mr. Robert Giffen, Professor Alfred Marshall, Mr. J. B. Martin, Professor J. S. Nicholson, Mr. R. H. Inglis Palgrave, *and* Professor H. Sidgwick, *appointed for the purpose of inquiring and reporting as to the Statistical Data available for determining the amount of the Precious Metals in use as Money in the principal Countries, the chief forms in which the Money is employed, and the amount annually used in the Arts.*

The Committee hope to have shortly more materials to work on. The withdrawal of the pre-Victorian gold coin, which is the object of the Coinage Act of this year, will provide some data on which to base a more definite estimate of the amount of the actual circulation than has yet been possible. Pending the action of Government, and the result of certain inquiries which are being conducted by two members of the Committee, Messrs. Martin and Palgrave, the Committee recommend that they should be reappointed.

value of money' [of which the measure is our Indefinite Standard] from variations in the 'power of money' [of which the measure is our Consumption Standard] (*Revue Sommaire*, p. 121). Referring to Jevons' proposal to construct a *Tabular Standard of Value*, Cournot expresses his approbation in words which may fittingly conclude the present study:—'Ce sont là des idées qu'il faut laisser mûrir. Quand le moment sera venu de construire effectivement *l'étalon monétaire*, les géomètres pourront y trouver une application intéressante de leur *Théorie des Moyennes*, telles qu'ils l'ont déjà construite pour les besoins de l'astronomie et de la physique.'

Report of the Committee, consisting of General J. T. WALKER, Mr. H. W. BATES (*Secretary*), General R. STRACHEY, Mr. W. T. THISELTON-DYER, *and* Professor W. BOYD DAWKINS, *appointed to investigate the Geography and Geology of the Atlas ranges in the Empire of Morocco.*

Report to the Committee. By JOSEPH THOMSON.

IN laying before the General Committee of the British Association a general report on the results achieved by my expedition to the Atlas Mountains, I gladly take the opportunity of cordially thanking the Committee for its substantial and welcome grant of 100*l.* towards the expenses of the work.

Briefly stated, I left England on March 9, 1888, and returned home in October of the same year, my explorations prematurely, and, as it turned out, quite unnecessarily, cut short by a summons to take command of an expedition for the relief of Emin Pasha.

In summarising the results of these seven months' travel in what Sir Joseph Hooker describes as the most difficult of all countries to explore (an opinion in which I heartily agree), it will perhaps be well to consider them under their various heads of Geography, Geology, &c.

I. *Geography.*—It is unnecessary to dwell on my travels in the more frequented parts of Morocco. New ground was first touched on my arrival at Demnat among the lower ranges of the Atlas.

From Demnat I made two excursions across the secondary heights of the great range, on both occasions reaching close to the central crest. By these trips I was enabled to map out the upper course of the Wad Demnat, and partially of the Wad Tessaout. Among other discoveries of an interesting nature in this region, I may refer to the remarkable natural bridge-aqueduct of Iminifiri, which spans a deep narrow gorge, and not only carries a stream of water from one side to the other, but is also used as a bridge by the inhabitants. Noteworthy also were some extensive ancient ruins on the top of Mt. Irghalusor, and a great series of artificial caves at Tasimset.

My next line of exploration lay up the glen of the Wad Gadat from Sidi Rehal. By this glen I penetrated to the very heart of the Atlas, and crossed to the southern side of the mountains by the Tizi-n-Teluet. From the valley of Teluet I made several minor excursions, in one of which I ascended Jebel Taurirt (11,168 ft.), the first occasion on which the summit of the Atlas had been reached in this part.

Proceeding further west, a new attempt was made on the mountain fastnesses from Amsmiz. Following the Wad Amsmiz to its source, the Atlas was again crossed by the pass of Nenieri (9,962 ft.), the head-waters of the Wad Nyfis were explored, and the southern slopes reached by penetrating the canyon of the Wad Agandice. Returning to the Plain of Morocco, the lower mountain course of the Wad Nyfis was traced out, and Amsmiz reached by the Tizi-n-Gerimt (7,215 ft.).

Further west from Amsmiz the Asif-el-Mel offered a new means of access to the main chain. This glen I explored as far as was practicable, and then, leaving it, crossed by a new pass, the Tizi-n-Nslit (9,715 ft.), to

the head-waters of the Wad Nyfis, from which I made the ascent of Jebel Ogdimt (12,734 ft.), the highest point of the Atlas west of the Wad Nyfis. Amsmiz was again reached by traversing the lower ranges.

Six weeks were unavoidably passed in the city of Morocco, the time being profitably enough spent in a study of the social and political life of the Moors.

On leaving the city an attempt I made to penetrate the glen of Wad Urika failed.

I was more fortunate by way of the Reraya. The glen of its principal tributary, the Wad Iminnen, was followed to its head, from which an ascent of the central crest was again achieved at the Tizi Likumpt (13,150 ft.). From this point the Tizi-n-Tamjurt could be seen to rise 1,500–2,000 ft. higher, being probably the highest peak in the entire range.

From Reraya I passed on to Imintanut, from which I made my final passage of the range, and determined to my satisfaction that the Atlas Mountains properly so called end at the Asif Ig, thirty miles from the coast, the further continuation of the elevated land being in the form of a triangular plateau 4,000–5,000 ft. in height. From Agadir, where the coast was reached, the base of this triangular plateau was skirted as far as Mogador.

From Fez as a centre it had been my intention to make a series of trips into the mountains, similar to those undertaken from the city of Morocco; but the summons already alluded to stopped me *en route* at Casablanca, and prematurely put an end to my explorations.

Such as it was, however, from what I was able to do, a clearer and more exact idea of the Atlas Range west of Demnat has been obtained, and its glens and mountains mapped with some approach to scientific accuracy by means of astronomical observations, careful triangulation with the prismatic compass, and route protraction with the ordinary compass. The central crest of the range has been reached at seven independent points, and heights attained exceeding previous travellers as much as 2,000 ft. Several new glens have been explored, and six passes crossed, and generally much new light has been thrown on the physical configuration of the Atlas. On these points it is unnecessary here to enter upon further detail, as I have the honour to forward along with this report the paper and map submitted to the Royal Geographical Society.

II. *Geology.*—Turning to geology, I am happy to report that, in spite of manifold difficulties and obstacles, I have been able to gather together sufficient material from which to construct a geological map of the Atlas Range between Demnat and the Atlantic. With the exception of the work done by Maw and Hooker in 1872, absolutely nothing has hitherto been done to throw light upon the geological structure of these mountains. The comparative absence of vegetation, and the numerous deep gorges and glens cutting right into the heart of the range, in some sort went to counterbalance the incessant espionage and suspicion which dogged my every movement, and made the collecting of specimens an impossibility.

The results of my geological investigations have been embodied in a paper on the Geology of the Atlas and Southern Morocco, which, along with a number of diagrammatic sections and a map, I propose to lay before the Geological Society of London.

Briefly stated, my exploration of the mountains between Demnat and the sea show that they consist—

(1) Of a central core or nucleus of metamorphic slates and crystalline limestones, at places much disturbed by intrusive bosses, dykes, and veins of porphyrites, basalts, and diorites.

(2) Of an enormous series of red and purple shales, marls, and sandstones forming the great mass of the chain, at some points, as at Taurirt, rising to an elevation of even 11,000 feet. These, as far as can be ascertained, belong to the Cretaceous series.

(3) Of an upper series of Cretaceous cream and grey-coloured limestones and sandstones, with fossils at places, among which have been determined *Trigonia*, *Arca*, *Rhynchonella*, *Astrea*, *Gryphæa*, *Astarte*, and *Lucina*. These series attain but a small development in the Atlas, as compared with the lower series, and are to be found only in the lower outer mountain terraces or steps. They are characterised by numerous intrusive bosses and great dykes of amygdaloidal basalts, which break through them along the whole length of the mountains from Demnat westward. In the plateau of Southern Morocco the red shales and sandstone series are masked by the limestones, except where some disturbance has brought the former to the surface.

(4) Of later formations nothing has been satisfactorily determined. Of glacial deposits there were little more than indications at the heads of some of the glens, and at one or two places in sheltered nooks, as in the glen of the Wad Nyfis. Slightly more important accumulations were observed in the valley of Gindafy, Wad Nyfis, and in the glen of the Urika. Moraines were detected between the Wads Gadat and Misfiwa; and in the Valley of Teluet. On the Plain of Morocco transported boulders were remarked. Upon the whole, evidences of glaciation were insignificant, and in those parts I explored I saw nothing anywhere in any way comparable to the enormous deposits described by Maw, of the soundness of whose conclusions as to their being of glacial origin I have the gravest doubt.

III. *Botany*.—On the botany of the expedition I have little to say, beyond explaining the extreme smallness of the collection brought back—a list of which, drawn up at Kew, accompanies this report. The whole of the time spent in the mountains was in the very driest and hottest season of the year, when for nearly eight months scarcely a drop of rain falls. The consequence is that the mountains, even to the highest points, are quite bare, and only along the courses of the streams are any plants to be found. I left Morocco just as the first autumnal rains began to fall.

Very much the same remarks apply to the collection of beetles. A list of specimens secured is appended.

Geology.

Atlas Expedition. Joseph Thomson.

Asif-el-Mel, Marossa.—Hard cream-coloured limestone, largely composed of casts of shells, badly preserved, among which *Trigonia* and *Arca* seem to be most abundant, but none are specifically determinable. Probably of Oolitic age.

District of Ait Musa, Mtuga.—Hard dark limestone, weathering red and brown, filled with large globular Rhynchonellæ, much resembling *R. tetrahedra.* Possibly Liassic.

Imintanut.—Soft shaly limestone, with numerous oysters allied to *Ostrea subrugulosa.* Probably Oolitic.

Head Waters of the Asif-el-Mel, Marossa.—Hard, cream-coloured, with three or four shells of uncertain genus.

Loe (?)—A rubbly limestone, containing many shells of *Gryphæa, Trigonia, Arca, Astarte,* and *Lucina.* Probably Oolitic.

G. SHARMAN and E. T. NEWTON.

Geological Survey Office, London,
August, 1889.

BOTANY.

Clematis flammula, L.
Adonis æstivalis, L.
,, *microcarpa*, DC.
Ranunculus, sp. nov. (to figure).
,, *chærophyllus*, L. forma.
,, *bulbosus*, L., var. *neapolitanus*.
Sarcocapnos crassifolia, DC., forma *parviflora* ?
Nasturtium officinale, R. Br.
Arabis auriculata, Lam.
Barbarea (?) n. sp.
Alyssum alpestre, L., var. *serpyllifolium*.
,, *montanum*, L. ? (scrap).
,, *spinosum*, L.
Erophila verna, R. Br.
Sisymbrium Thalianum, J. Gay.
,, *Sophia*, L.
Erysimum australe, J. Gay (forms ?)
Brassiea humilis, DC.
Biscutella apula, L., var. (*B. microcarpa*, DC.)
Lepidium nebrodense, Raf., var. *atlanticum*.
Isatis tinctoria, L., var. *lætivirens*, J. Ball.
Crambe hispanica, L. (*C. filiformis*, Boiss. an Jacq.)
Cossonia platycarpa, Coss.
Capparis spinosa, L.
Reseda propinqua, R. Br. var. ?
,, *luteola*, L., var. ?
Helianthemum glaucum, Pers.
,, *rubellum*, Prese.
,, ,, ?
Silene, sp. n. (to figure in Ic. Pl.)
,, *mellifera*, Boiss. and Reut.
,, *inflata*, L.
,, *an S. longicaulis* var. ?
Arenaria serpyllifolia, L. forma.
,, *pungens*, Claus.
,, *procumbens*, Vahl.
Cerastium arvense, L.
Linum angustifolium, Hud.
Geranium pyrenaicum, L.
,, *Robertianum*, L.
Erodium cicutarium, L. forma.
,, ,, sub. sp. *E. Jacquinianum* ?
,, *malachoides*, Willd.

Ruta chalepensis, L., var. a. (*R. angustifolia*, Pers.)
Adenocarpus anagyrifolius, Coss. et Bal.
Genista florida, L., var. *maroccana.*
Cytisus Balansæ, Boiss., var. *atlanticus.*
Ononis Thomsoni, Ball MSS. (to figure).
,, *viscosa*, DC., var. *angustifolia* ?
an Medicago suffruticosa, Ram. ?
Trifolium, cf. *T. humile*, Ball.
Anthyllis vulneraria, L.
Erinacea pungens, Boiss.
Astragalus ochroleucus, Coss.
Lotus corniculatus, L.
Potentilla reptans, L.
Saxifraga granulata, L. var.
Ribes grossularia, L., var. *atlantica*, Ball.
Cotyledon umbilicus, L., var. *horizontalis.*
Sedum altissimum, Poir. ?
Apium nodiflorum, Bth. and Hk. (*Sium nodiflorum*, L.)
Pithranthus scoparia (*Deverra scoparia*, Coss.)
Galium corrudæfolium, Vill.
,, *Poiretianum*, Ball.
,, *acuminatum*, Ball.
Asperula hirsuta, Desf.
Valerianella pumila, DC.
Bellis sylvestris, Cyr.
,, *cærulescens*, Coss.
,, ,, forma *radiis albescentibus.*
Gnaphalium helichrysoides, Ball.
Anacyclus depressus, Ball.
Achillea ligustica, All.
Anthemis arvensis ? an potius *A. tuberculata.*
,, *tuberculata*, Boiss.
,, *heterophylla*, Ball, 'Journ. Linn. Soc.,' xvi., 507.
Chrysanthemum catananche, Ball.
,, A.
,, B.

At first sight I should refer the specimens marked B to *C. atlanticum*, Ball, and regard those marked A as a distinct and new species; but I am at present inclined to think that these, with *Pyrethrum Maresii*, Coss., must be united and regarded as forms of one species. What name that species should bear is another question. *Pyrethrum Maresii* is the older name, but *C. atlanticum*, Ball, will, I suppose, be taken by those who refer all these to *Chrysanthemum.*

I do not think, however, that the preliminary question can be decided until we have mature fruits of all the forms. It appeared to me long ago that the achene of *C. atlanticum* is somewhat different from that of *P. Maresii*, but there may be intermediate forms.—[Note by Mr. Ball.]

Centaurea salmantica, L.
Calendula suffruticosa, Vahl.
Catananche cærulea, L.
Hieracium Pilosella, L. var.

Andryala tenuifolia, Coss. an DC.
,, *integrifolia*, L. var.
Hypochœris radicata, L.
Leontodon autumnalis, L.
,, *helminthoides*, Coss., var. nisi sp. nov.; desunt achenia.
Lactuca tenerrima, Pourr.
Picridium?
Microrrhynchus spinosus, B. and Hk.f.
Sonchus asper, Vill. (bis).
Campanula pilicaulis, Dur. (bis).
Armeria allioides, Boiss (bis ?).
Cynoglossum pictum, Ait.
Myosotis sylvatica, var. *alpestris* (bis).
,, *stricta*, Link (bis).
Echium plantagineum (L.)
Linaria græca, Bory and Chamb.
,, *ventricosa*, Coss.
,, *heterophylla*, Desf. (bis).
,, *galioides*, Ball.
,, *Tournfortii*, var. *minor*, Lge.
Anarrhinum fruticosum, Desf.
Veronica Anagallis, L. (bis).
,, *Cuneifolia*, Don., var. *atlantica*, Ball (bis).
Verbena officinalis, L.
Scrophularia canina, L., var.
Lavandula tenuisecta, Coss ?
Thymus lanceolatus, Desf., var. *crispus*, Ball.
Micromeria microphylla, Benth. var.
Calamintha Acinos, B.
,, *alpina*, B.
,, *Clinopodium*, B. var. vel sub sp. *C. atlantica*, Ball.
Salvia taraxacifolia, Coss.
Nepeta atlantica, Ball.
Sideritis villosa, Coss. (4 sheets).
Manubrium vulgare, *β lanatum*, Benth.
Lamium amplexicaule, L.
,, *flexuosum*, Trn., new to South Morocco.
Teucrium collinum, Coss., var. ?
Ajuga Iva, Schreb.
Plantago Coronopus, L., var. *cupani* (bis).
Globularia alyssum, L.
Paronychia argentea, Lam.
,, ,, var. ?
Rumex pulcher, L.
,, *thyrioides*, Desf.
,, *scutatus*, L.
,, ,, var. *induratus*.
,, *atlanticus*, Coss.
Euphorbia luteola, Coss., new to Morocco.
,, *pubescens*, Vahl.
,, *helioscopia*, L.
Salix purpurea, L., var. *Helix*.
Orchis latifolia, L., var. *Durandii*.

Ornithogalum umbellatum, L.?
„ *tenuifolium*, Guss.?
Dactylis glomerata, var. *hispanica*.
Festuca?
Cistopteris fragilis, Bernh.
Asplenium Trichomanes, L.
„ *Ceterach*, L.
Notochlæna vellea, Desf.

List of Coleoptera taken by Mr. Joseph Thomson on the Atlas Mountains, Morocco. By B. G. NEVINSON, *M.A., F.Z.S.*

This collection consists chiefly of species of the Heteromerous section of the order, and, though a small one, contains some very interesting forms. It is curious to observe that most of the species differ more or less from the normal types, and that this difference is mostly in the direction of smoothness of surface. Possibly this may be accounted for by the elevations at which the collection was formed (6 to 10,000 ft.). All the specimens come from Glauwa and Amsmiz, the majority from the latter locality. Number of specimens, 138, belonging to 31 species:—

Pachychila, Esch.
Angulicollis, Fairm.
glabra, Stev.
Morica, Sol.
Favieri, Luc.
planata, Fabr.
Akis, Herbst.
elegans, Charp.
Heydenii, Haag.
Scaurus, Fabr.
sticticus, Germ.
uncinus, Forst.
Blaps, Fabr.
Armeniaca, Fald.
barbara, Sol.
Emondi, Sol.
tæniolata, Men. Although this is a very westerly locality for this species, I can find no character to separate the two specimens procured by Mr. Thomson from those labelled *tæniolata* by Mons. Allard in Mr. F. Bates's collection, now in the British Museum.
Pimelia, Fabr.
Boyeri, Sol.
malleata, Woll. Of this pretty species there are two examples in the British Museum in the collection which formerly belonged to Mr. F. Bates, one of which bears the label '*Malleata*. Wollast. type.' They were also brought from the Atlas Mountains, having been taken by Messrs. Hooker and Ball. Mr. Thomson collected thirteen specimens.
simplex, Sol.
rotundipennis, Kraatz.
Thomsoni, Nev. Ent. Mo. Mag. vol. xxv. p. 255.

Hopatrum, Fabr.

Hookeri, F. Bates.

Omophlus, Sol.

distinctus, Cast.

Meloe, Linn.

Scabriusculus, Brandt ? *prox.*—The solitary specimen is too much damaged for positive identification, but it has the same very short thorax as *scabriusculus*, and similar sculpture on the elytra.

Mylabris, Fabr.

circumflexa, Chevr.

duodecimpunctata, Oliv.

Silbermanni, Chevr.

variabilis, Pall., var. *tricincta*, Chevr.

Included in the collection there are also a few species belonging to other families of *Coleoptera* :—

Fam. *Carabidæ.*

Calosoma sycophanta, Lin.—A fine variety, in which the elytra are almost entirely of a brilliant golden coppery hue.

Acinopus, sp. ?

Fam. *Trogositidæ.*

Trogosita (*Alindria*, sp.).

Fam. *Scarabœidæ.*

Phyllognathus Silenus, Fabr.

Oryctes nasicornis, Lin.

Tropinota, sp.

Oxythyrea stictica, Lin.

Oxythyrea amina, Fairmaire.

Fam. *Chrysomelidæ.*

Timarcha scabripennis, Dej.

,, *turbida*, Erichs.

,, *pimelioides*, Schaf. ?

Fam. *Coccinellidæ.*

Coccinella septempunctata, Lin.

Fam. *Buprestidæ.*

Julodis intricata, Redt. ? ?

Fourth Report of the Committee, consisting of Professors TILDEN *and* ARMSTRONG (*Secretary*), *appointed for the purpose of investigating Isomeric Naphthalene Derivatives.* (*Drawn up by* Professor ARMSTRONG.)

THE study of naphthalene derivatives has been prosecuted in the reporter's laboratory during the past year with far greater success than could have been anticipated, chiefly owing to the untiring energy and skill of Mr. W. P. Wynne; valuable assistance having also been rendered by several students. The results are, it is believed, of considerable importance from a theoretical point of view, not merely in relation to naphthalene derivatives, but in connexion with the general problem of the nature of the changes involved in the production of isomeric compounds.

Constitution of the isomeric dichloronaphthalenes.—A list of the twelve reputed dichloronaphthalenes was given in the last report, and their constitution was provisionally discussed. The results since obtained render it possible to finally assign the proper formulæ to the several modifications, the method adopted affording almost if not quite as absolute a determination of their constitution as that employed by Körner in the case of the dibromobenzenes: an account thereof is given in the 'Proceedings of the Chemical Society,' 1888, pp. 104–107; 1889, pp. 34–37; pp. 48–54. The conclusions arrived at by Erdmann and Kirchhoff are confirmed; as the synthetic method which these chemists had adopted was one which did not exclude the possibility of the occurrence of isomeric change, objection was taken to their proof in the last report, but it is now clear that they had correctly interpreted their results.

The so-called α-dichloronaphthalene, m.p. 38°, obtained by the action of alcoholic potash on naphthalene tetrachloride, has been proved to be a mixture of 1 : 4 (β) dichloronaphthalene, m.p. 68°, and 1 : 3 (θ) dichloronaphthalene (m.p. 61°). (Cf. 'Chem. Soc. Proceedings,' 1888, 106.) It has previously been pointed out that the so-called κ-dichloronaphthalene of Claus has no claim to recognition, and that it is doubtful whether the ι-dichloronaphthalene described as melting at 120° was a pure substance: consequently at present but nine of the ten possible dichloronaphthalenes are to be regarded as beyond doubt existent; their constitution is as follows:

—	M.P.	Position of Radicles
αα. Modifications :—		
β. Dichloronaphthalene	68°	1 : 4
ζ. "	83°	1 : 1′
γ. "	107°	1 : 4′
ββ. Modifications :—		
δ. "	114°	2 : 2′
ε. "	135°	2 : 3′
αβ. Modifications :—		
"	34°	1 : 2
θ. "	61° (about)	1 : 3
θ′. "	63° "	1 : 2′
η. "	48°	1 : 3′

The alpha-law. Spontaneous occurrence of isomeric change on sulphonation.—In previous reports attention has frequently been directed to the circumstance that, as a rule, *alpha*-derivatives are formed, and that *beta*-derivatives are only obtained either when a group is present in an alpha position which determines the entry of the new group into the contiguous beta position, or owing to the occurrence of secondary change: it has in fact been argued that an isolated beta position is never directly attacked. Further evidence tending to strengthen this conclusion has recently been obtained. When either β-chloro- or β-bromonaphthalene is sulphonated, the chief product is the 2 : 1′ α-acid; and a relatively very small amount of the isomeric 2 : 3′ β-acid is also obtained, and it was suggested that this was formed by spontaneous isomeric change from the 2 : 1′ acid, as it was found possible to convert the α- into the β-acid by heating. β-iodonaphthalene in like manner was found to yield two sulpho-acids, but it was pointed out in the second of these reports that the melting point of the sulphochloride of the acid found in small quantity was remarkably low.

Recent experiments of Mr. Houlding (cf. 'Chem. Soc. Proceedings,' 1889, 74) have served to show that the minor product is not the 2 : 3′ derivative. Subsequently Mr. Wynne and I have found (ibid. 1889, 119) that the chief product of sulphonation in the case of β-iodonaphthalene corresponds with the chief product afforded by β-chloro- and β-bromonaphthalene, and that the minor product obtained from β-iodonaphthalene is the second heteronucleal 2 : 4′ *alpha*-sulphonic acid: so that whereas only one alpha-acid is obtained on sulphonating β-chloro- and β-bromonaphthalene, β-iodonaphthalene yields the two possible heteronucleal alpha-acids. Both β-iodo α-sulphonic acids, however, are found to yield the same 2 : 3′ β-sulphonic acid when heated at about 150°. It is therefore not improbable that on sulphonating the chloro- and bromo- compounds, two *alpha*-acids are initially formed, and that one of these forth with undergoes spontaneous isomeric change into the 2 : 3′ acid.

The results obtained in the case of the dichloronaphthalenes tend to support this view. Thus 1 : 3 (θ) dichloronaphthalene affords but a single sulphonic acid; this product is identical with that prepared by Widman from naphthalene-α-sulphonic acid and is in all probability the 1 : 3 : 4′ acid.

1 : 2 dichloronaphthalene, however, yields two isomeric acids, the chief product (about 2-3rds) being the 1 : 2 : 4′ (α) acid, the subsidiary product the 1 : 2 : 3′ (β) acid; as the latter is almost the sole product if the original product of sulphonation be heated at 150°-160° during several hours, it is probable that the β-acid in the original product is formed by spontaneous isomeric change at the moment of sulphonation.

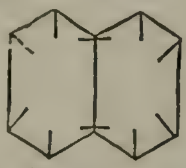
1 : 4 (β) dichloronaphthalene, however, yields as sole product the 1 : 4 : 2′ (β) sulphonic acid, and it would appear that isomeric change takes place in this case spontaneously and with exceptional facility and completeness.

1 : 4′ (γ) dichloronaphthalene yields as chief product (about four-fifths), the 1 : 4′ : 2′ betasulphonic acid (m.p. of sulphochloride 139°–140°), together with what appears to be the isomeric 1 : 4′ : 3′ beta-acid (m.p. of sulphochloride 98°–100°); in this case it is possible that an alpha acid is first formed, which at once changes, but more probably the two alpha positions are 'protected' by the two alpha-chlorine atoms, the 1 : 4′ : 3′ beta acid being first formed, and at once partly converted by spontaneous isomeric change into the more stable 1 : 4′ : 2′ acid. It is obvious that much important information is to be obtained by further study of the subject.

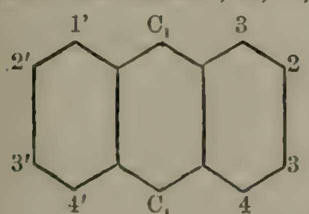
Azo-dye stuffs derived from naphthalene.—In the second of these reports it was argued that the azo-dye stuffs from betanaphthol were all 1 : 2 α–β derivatives, and as a matter of course the argument would apply equally to betanaphthylamine. Experiments were commenced with the object of obtaining the data required to verify this theory, but their continuance became unnecessary in consequence of the publication of a valuable paper by Dr. O. N. Witt ('Berichte,' 1888, 34–68), in which it is demonstrated that the azo-colours from the free isomeric betanaphthylaminesulphonic acids and a number of others are all 1 : 2 derivatives. In pointing out (cf. *second* report) that the formation of the azo-colour involves an isomeric change which apparently can take place only in the one direction, and that on this account it is impossible to effect the introduction of the azo-group into any other position than that contiguous to the OH or NH_2 group, no special note was taken of the

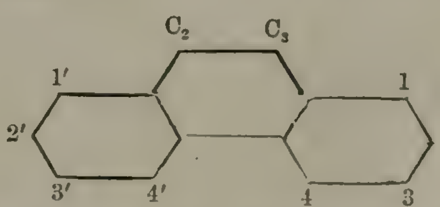
peculiar constitution of the colouring matters themselves; the further study of this question, however, has led me to the conclusion that even if the transference could be effected in any other way azo-colours would only result provided that 'quinonoid' compounds were formed; at present this is only known to obtain in the case of the 1 : 2 and 1 : 4 compounds (cf. 'Chem. Soc. Proceedings,' 1888, p. 27).

The symbol of naphthalene.—There appears to be a tendency on the part of some recent investigators of naphthalene derivatives to consider that the naphthalene molecule is dissymmetric. Without discussing this question in detail I would express my conviction that this is not the case, and that the behaviour of naphthalene, and especially its characteristic tendency to form alpha-derivatives, may be satisfactorily expressed by means of a symbol similar to that which I have suggested for benzene ('Phil. Mag.,' Feb. 1887), viz.:



Notation of naphthalene derivatives.—Throughout these reports, &c., the system of notation introduced many years ago by the Chemical Society and in 'Watts' Dictionary of Chemistry' has always been made use of, and its general adoption was advocated in a recent paper by Mr. Wynne and myself (cf. 'Chem. Soc. Proceedings,' 1889, p. 54). It consists in numbering the positions in the one nucleus 1, 2, 3, 4, and the corresponding positions in the second nucleus 1′, 2′, 3′, 4′. The practice of numbering the positions 1 to 8 appears less desirable and rational in view of the fact that naphthalene consists of two like nuclei, and of the importance of at once being able to recognise which are corresponding positions. In a recent conference at Paris it was, however, resolved to recommend the system of numbering the positions 1 to 8, but this decision appears to have been arrived at without any sufficient discussion of the question or pains being taken to consult those who have the right to express an opinion. The desirability of numbering corresponding positions similarly in all multinuclear compounds cannot be denied, and it is very easily carried into practice; thus in the case of anthracene the positions in the one *lateral* nucleus are 1, 2, 3, 4, in the other 1′, 2′, 3′ 4′, and in the *central* nucleus C_2, C_3; in the case of phenanthrene those in the central nucleus are C_1, C_4, those in the one *lateral* nucleus 1, 2, 3, 4, those in the other 1′, 2′, 3′, 4′. Thus:





Anthraquinone is a 1 : 4 *centri*-di-derivative, phenanthraquinone a 2 : 3 *centri*-di-derivative.

Report of the Committee, consisting of Dr. GARSON, Mr. BENT *(Secretary)*, Mr. PENGELLY, Mr. RUDLER, Mr. BLOXAM, *and* Mr. J. STUART GLENNIE, *appointed to investigate the Habits and Customs and Physical Characteristics of the Nomad Tribes of Asia Minor, and to excavate on sites of ancient occupation.* (*Drawn up by the Secretary.*)

OUR researches into the manners and customs of nomad tribes this last spring were carried on in the district known as Azerbeijan, bordered on the west by Lake Urmia, on the south by Kourdestan, on the north by the Russian province of Transcaucasia, and on the east by the Persian province of Irak Adjemi. Azerbeijan represents the ancient Atropatene, the kingdom of Media, and is composed of vast, and in many cases inaccessible, mountain ranges, overrun during the summer months by tribes of Kurds and Tatar-Turks and Arabs who come up from the burnt-up district of the Germseer to find pasturage for their flocks. The low-lying ground around Lake Urmia, Urumia, or Lake of the Armenians (darya i Armeni), as the Persians call it, has a settled population, inhabiting such towns as Maragha, Binab, Mianduwab, Urmia, &c., consisting of a mixed population of Persians, Tatar-Turks, Armenians, Nestorians, and the remnants of the ancient race of the Chaldeans. For ethnological study the province of Azerbeijan, therefore, offers one of the most profitable fields, but owing to the unsettled state of the country it was necessary for us to take a considerable escort with us, and to secure the friendship of the chiefs of the various tribes through whose territory we passed.

The preparations for our journey were made at the town of Zenjan, the border town of Persia proper, and the first district where the Tatar-Turkish language is spoken; it has obtained a disagreeable notoriety in later years as the centre of the Baabi conspiracies against the present dynasty in Persia, and has suffered much from the outbreak of revolutionists. We left this town, accompanied by Mirza Hassan Ali Khan, chief secretary of Animi-Sultan, the Persian Grand Vizier, a yuz-bashi, or captain, and several other attendants.

The first part of the country we traversed was very fertile, and at a distance of 12 miles from Zenjan we halted in a garden of the village of Gul-i-Khandi, before commencing the mountainous tracks; here the inhabitants all spoke Tatar-Turkish, and Persian ceased to be understood. Passing over several ridges of mountains we reached the village of Gul-tepe, close to which were several mounds with ramifications of minor construction, betokening the existence of a town of considerable importance during the Median epoch. Close to here gold has been found, and we were shown several shafts that had been sunk into the mountain side by the late Grand Vizier, but now abandoned, as the results were unsatisfactory.

At a distance of 28 miles from Zenjan we halted for the night, at the mud village of Dehshir, the first of many villages inhabited by the Afshah tribe, one of the most important of the Tatar-Turkish tribes. These villages during the colder months of the year are inhabited; when the summer heats come on the inhabitants migrate to the mountains with

their flocks and tents. The history of the Afshah tribe would appear to be lost in obscurity; all that is known of them is that, in 1508, this tribe, in conjunction with six others, succeeded in assisting Shah Ismail in his wars, and obtained from him certain privileges, one of which was that of wearing a dress peculiar to themselves, and a red cap, which gained for them the Turkish name of Kizil-bashi, or red-heads.

The mud villages inhabited by the tribes closely resemble one another: they are principally conspicuous for certain round constructions standing about 15 feet in height, and built in the form of a dome. These are made of dried cakes of dung, and are the only fuel possessed in the district. Each house has one, and the cakes are made by spreading the dung of their animals on a flat space before the house, mixing it with mud, and when it has assumed the desired consistency they plaster the cakes on to the walls to dry, and then build them up into the round structures called *kusks* or kiosks, and the fuel is called *bardans*; women are generally employed in making this kind of fuel. Over the houses of most of the inhabitants may be seen the skulls of horses or donkeys placed there to keep off the evil eye. On entering the village we interrupted a Passion Play of the most primitive description. Many *gelims* and nummuds, or carpets made by the tribe, were spread over the chief place of the village. The performers, dressed in coats-of-mail and brandishing the daggers and weapons commonly found amongst them, performed the play of Houssein and Hassan; whilst the male spectators wept as if their hearts would break, and the women uttered screams of distress. After the happy denouement they all got up, and with hands spread towards Kerbela, thanked Allah for mercies vouchsafed. I have seen these plays often in Persian towns, but never with the intensity of feeling and passion shown amongst these wild mountaineers. The collection of individuals at the play gave us an opportunity of noticing the principal features of the inhabitants: their eyes are small, they have high cheek-bones, their beards thin and straggly, and their frames very robust.

Outside the village is the grave-yard, in the centre of which is a tiny circular tomb of mud over the body of a Seid, or holy man of the tribe. On either side of his tomb were poles for decoration at the annual festival of the Mohurrim. The Afshah tribe belongs to the Shiah faith, as do most of the Tatar-Turkish tribes, whereas their hereditary enemies of the Kourdish tribes are almost universally Sonnee. At funerals they generally take the riderless horse of the deceased to the grave.

About four miles from Dehshir, at the village of Tschaierli, we commenced the ascent of a very high pass, and then descended into the bed of the Kizil-Uzen river. This pass is called Ali-panj-Angoost, or the five fingers of Ali, from some peculiar pointed rocks which are greatly venerated by the tribes, and all around were little piles of stones placed by passers by in token of respect—the same idea commonly seen throughout Persia, for whenever travellers come within sight of some sacred shrine they add a stone to the many piles around them. There are several villages on a plain of considerable fertility, by the banks of the Kizil-Uzen river, Dooskhandi, or salt-diggers' village, so named from the fact that rock-salt is obtained from the mountains behind. The Kizil-Uzen is one of the most important rivers of Media, rising in Mount Zagros, in Kourdestan, and after a meandering course of about 490 miles, flowing into the Caspian. It is supposed to be the river Gozan (2 Kings xvii. 6), and is certainly the most important stream between the

Caspian and the lakes of Urmia and Van. We crossed it with considerable difficulty, owing to the swollen waters, at the village of Bagtash, and then ascended by the side of a stupendous gorge to a level plateau covered with horses and animals belonging to the tribes, enjoying a rich pasturage. The horses are mostly bred from Arab sires, and with the rich pasturage become very fine specimens.

Our next halt was at the village of Savandi, where we were accommodated in a newly-constructed house belonging to Kerim Khan, the chief of the Shah-Savand tribe, of all the tribes of this district the most conglomerate and the most aristocratic. It was founded by the great Shah Abbas, who ruled in Persia at the beginning of the seventeenth century, to counteract the influence of the Kizil-bashi, or Red-caps, one of the Afshah tribe at that time having aspired to the throne. He summoned volunteers from all the tribes of his dominions and enrolled them as his body-guard, and by this means got together a body of men 10,000 strong. He gave them grants of land, and incorporated them as the Shah-Savand tribe, or 'friends of the Shah.' During all the period of the Sufi dynasty they had great influence in Persia, but when the present family came to the throne their position was eclipsed by the Kadjar tribe, from which the present ruling-house has sprung. Kerim Khan was absent in attendance at Court when we were there, but we had the pleasure of prescribing for his wife, who lay ill of congestion of the lungs, and before we left we heard of her favourable progress towards recovery. Amongst the Shah-Savand tribe are many Kourds; we saw a wedding going on amongst them, and witnessed, for the first time, the Kourdish dance of Tchopee. A ring of dancers, not joined at the ends, is formed; these go through certain evolutions bearing a close resemblance to the dances I have witnessed in the Greek islands, called the Syrtos. The women, in red with gold ornaments and uncovered faces, looked highly picturesque. The music consisted of a flute (surmeh) and a drum (duhool). Each woman carried in her hands a red handkerchief, which she flourished as she went round.

We learnt a good deal at Savandi about the constitution of the tribes. The chief is usually made a Khan by the Persian process of sending him a coat-of-honour and other dignities, for which he has much to pay. He remains with his people, but he has a vakeel or representative at Court, generally a son or near relative, who combines the office of transacting business with that of acting as a hostage for the good behaviour of his tribe. Any man of rank in the tribe can demand a council of the elders or white-beards; the mollahs or priests expound the law at these assemblages. The office of chief, called the 'pir' or elder of the tribe or 'eel,' is hereditary, and the 'pir' generally traces his descent from some holy man, whose worship is general throughout the tribe, and called the Ojak; his tomb is generally in some well-known spot amongst their summer haunts, and a great object of veneration.

Each tribe has its recognised district and lines of demarcation of pasturage, which have been observed from remote ages, and are visited summer after summer by the flocks with unceasing regularity. In the district through which we travelled the Afshah held most of the pasture land, and are very jealous of the encroachments of the Shah-Savand, who occupy their pasturage only by a very recent tenure. Concerning right of pasturage constant blood feuds arise amongst the shepherds, resulting in the extermination of whole families.

At the next village of Ghar-dare we first made the acquaintance of the underground houses, where the nomad tribes usually reside with their flocks during the winter months; these *zerder*, as they are called, are of different kinds. Here they are detected only by mud domes with holes at the top, over which the road passes, and at the top of which the village-life is carried on; not unfrequently accidents happen and a donkey or horse descends through the ceiling on to the family below. On the plain of Mianduwab, to the south of Lake Urmia, they are of a different form, slanting roofs appearing above ground, made of thatch. You descend into the rooms below by a sloping path; here you see the rooms, cupboards, and shelves (tarcheh) all hollowed out of the ground, but having seen one is quite sufficient, as you reach the surface one mass of fleas.

We passed many villages on our road in fertile valleys; of animal life we did not see much except wolves and vultures.

At Genjabad we were again entertained in the house of a chief of a branch of the Afshah tribe, Mousa Khan by name, and another day's journey brought us to the mud village of Baba Nazere, inhabited by Kourds, and close to some ruins which we proposed to study, so we here put up for several days and had ample opportunity of studying the inhabitants.

The chief of the village, Sarmas Beg, gave us up his house, a miserable mud tenement consisting of two rooms. The climate at this elevated spot was intensely cold and wet, even though it was in May, and for fuel we had nothing but the dung cakes which I have already alluded to. Sarmas Beg had three wives and seven stalwart sons, who always rode out to protect us when we went out, and performed for us many of the Kourdish horseback games. One, the 'bazi,' consisted of riding at full gallop in twos or threes before us with lances posed and trembling as if for casting; then, at the word of command, they executed a sharp turn and charged back again. Then they did for us the Kaygatch, or shooting at an object with a gun when at full gallop. The dexterity they displayed at shooting backwards when in the saddle and at full gallop, reminded us forcibly of Xenophon's account of the skirmishing capabilities of the Parthian archers. All Kourdish games are wild—beating with a rope at anyone who tries to catch an individual placed in their midst, dragging by the leg a man tied to another, who tries to touch one of his opponents without letting go of the unfortunate victim. But what interested us most at Baba Nazere was studying a peculiar form of religion which is common to many of these wandering races, and though our material for this study was collected at many other points I cannot do better than set it all out here.

By the Persians these people are called the Ali-ullah-hi, or sect who affirm that Ali, the son-in-law of Mahomed, is God; they call themselves 'the friends of the Seid,' or followers of Nazere, who is said to have founded this religion. One of the great centres of this religion is Genjabad, the village we passed through before reaching Baba Nazere, the name of which place I have little doubt is derived from their prophet. One Iman Kooli of Genjabad is reported to have dreamt that a landslip would destroy part of the village, which came to pass, and by reason of his prophecy many were saved. Each community of Ali-ullah-hi has a Seid, who presides at their secret meetings held in a room in the village. They have freemasonry signs by which they know each other, and, like the howling dervishes, they are great at fire-eating and other horrible tricks of juggling. These meetings, or zekker as they are called,

are curious, inasmuch as they contain many elements of Christianity. Each person as he or she enters kisses the hand of the Seid and takes up his place at the right of the last comer. A sheep is killed and roasted whole; it must be without blemish, and its horns and hoofs are first taken off; the man who cooks it must not taste it, and when all are assembled it is brought in, and the Seid distributes portions of it to each, each person's share being equal, be he great or small They have, too, a form of baptism, and pass children through fire, and at their assemblages they have cups of wine handed round. They have no mosques, only sacred tombs, where their Seids are buried, places where they say the holy light has come down, which, together with their worship of fire, connects them with the ancient Zoroastrians who lived in this district.

Their tradition is curious. Nazere, they say, was Ali's representative on earth; seven times was he killed by Ali, and seven times was he brought to life. Mahomed they assert to be God. Ali, his son, was also a part of the Godhead, who was sent to earth to convert people from their evil ways, and on his return to heaven he left an incarnation of the Deity always on earth, which incarnation is represented by Nazere and the succeeding Seids.

There is so much that is similar to Christianity in their religion as to make me hazard the suggestion that they are a branch of decayed Christians (many other branches occurring here, such as the Nestorians, Chaldeans, &c.), who, to preserve themselves from persecution, substituted the name of Ali, the great saint of the Shiah sect, for that of Christ, and in the lapse of ages have got a mixture of the two creeds The very name of Nazere is suggestive of Nazareth; then there is the passover, the baptism, and the curious fellowship between them, which is handed down from father to son. Many of the Eeliants, or wandering tribes, who come up to the mountains in the summer months, belong to this sect, and Sarmas Beg and his sons are said to be shining lights in the community. The Mahomedans proper attribute to this sect many horrible crimes; they say they are communists, and have their wives and property in common, but from personal observation I should say this is a libel pure and simple. My wife had occasion to visit Sarmas Beg's wives on several occasions for photography, and found them much as other women of the Mahomedan faith. To the casual observer the only outward feature noticeable in these Ali-ullah-hi villages is the absence of mosques, baths, and prayer, all such marked features in Mahomedan countries. My information on the subject has been obtained from varied sources, from Mirza Hassan Ali Khan, a Persian of great intelligence, from a converted Seid in the Ali-ullah-hi village of Ilkatchee, and from Armenian missionaries, and in the main the information from all these sources agrees.

Before Sarmas Beg's house stood his long lance, the evidence that the chief of the tribe dwelt within. When he is in his tent this lance stands before it.

About a mile from Baba Nazere are the ruins of Takht-i-Suleiman, ruins of doubtful origin, but probably dating only from the Suljukian period; they are situated in a very fertile hollow amidst the mountains, and are remarkable chiefly for a pond in the centre, which in overflowing petrifies all around it, so that excavating we found practically impossible. Close to it is a conical hill 200 feet high, with a hole a quarter of a mile round, sinking to the depth of the hill and formed by the same

action of water, which has since found another outlet, presumably the one in the centre of the ruins of Takht-i-Suleiman. A lofty mountain near has a fortress at the top, but owing to the depth of snow we were unable to visit it; this is known as Takht-i-Bulgais or Belkis, Bulgais being the name for the Queen of Sheba. The legends of Solomon in these parts are very curious. The ruins themselves are called Solomon's throne; a curious long formation of petrifaction which runs across the valley is supposed to be a serpent turned into stone at Solomon's command. The hole in the mountain is called Solomon's prison, and the ruins of a building are known amongst the peasants as Solomon's bath; these ruins are favourite summer quarters for the tribes with their flocks, and on casually asking their ideas respecting Solomon I was seriously told that inasmuch as Solomon was the wisest of mankind of course he chose the best spot in the world for his residence. In summer-time this may be true, but when we visited it the cold season was hardly sufficiently over to enable us to endorse this opinion.

At Baba Nazere we were joined by Mahomed Housein Khan, the third son of Haidar Khan, the chief of the Afshah tribe, together with a large retinue, who had been despatched to conduct us safely through the dangerous country which borders on Kourdestan. Haidar Khan apologised that his health would not permit him to come in person, but he sent us presents of a lamb, several loaves of sugar, and packets of tea. Some of these we distributed to our host, and we were much struck by the graceful way in which the Kourdish chiefs received the presents. They first kissed it, put it to their forehead, and then bowed; presently they brought us in return presents of cream, bread, and cakes, and on my wife saying that the bread was the best we had eaten on this journey, Sarmas Beg's son put his hand to his heart, and bowed like a Parisian.

On leaving Baba Nazere, Sarmas Beg and his sons, with the long lance, accompanied us for several miles, the old Persian custom of *istikbal*, to speed the parting guest, and then they took farewell of us with many protestations of good will, and we were handed over to the protection of Mahomed Housein Khan and the Afshahs. At the village of Akbulak our new protector had ordered a sumptuous repast to be prepared for us in the house of a relative, consisting of a large tray groaning under a weight of pilaw, kabobs, meat prepared with prunes and rice, thickened cream, mast, or curdled milk, fried eggs, sherbet in a blue bowl, sour milk, and bread wrapped up in a handsome cloak. He then conducted us to the village of Paderlu, inhabited by Afshahs, and close to a curious natural phenomenon—a floating island in the centre of a small highland lake. This floating island is called Chamli-gul, or the meadow of water, and consists of a thick mass of roots and reddish clay about 40 feet by 60; the thickness of the island at its edge is one yard and a half, and it moves from one side of the lake to the other according as the wind blows, approaching the edge of the lake so near that we could easily jump upon it. It is all covered with grass and reeds, and in the summer is a favourite pasturage for flocks. The lake itself is very deep, far deeper than I had any means of fathoming; it is surrounded by rich marl hills, covered with green, and backed up by the stupendous range of Seehend. During our stay at Paderlu the island changed its position four times.

The Afshahs of Paderlu have a bad reputation, and we were thankful

to be under the immediate protection of their chief. They are all shepherds, and possess a fierce race of dogs to keep off the wolves. We had an opportunity here of seeing how expert these people are in treating mud, mixed with dung, and bringing it into use for most purposes. Besides the kusks, or fuel domes, before alluded to, and on the top of most of which storks had built their nests, called here Hadgi laclacs, from the general idea that they always go to Mecca during the winter season, they make beehives of the same material, long barrels, which are stuck into the walls of houses, the inner end projecting into the apartment, and stopped up with a cake of dung; to take out the honey, the owner makes a noise in his room, drives out the bees, removes what honey he wants, and claps on another cake of dung; then, again, bowls for household purposes are made of it—in fact, it supplies everywhere in these parts the place of wood, which is exceedingly scarce in these treeless mountains.

Their chief food is '*mast*,' or curdled milk, and bread; on the tops of the houses we noticed many round white balls, which are made by pressing the curdled *mast*, mixing it with salt, and making a sort of very coarse cheese; the peasants in these villages eat little else. Outside the village we found that in the graveyards the tombs are covered with slabs made of the same mud and dung preparation. Most of the tombs are empty, for the wolves of the neighbourhood seldom leave the bodies long in the graves.

A two days' ride from Paderlu brought us to the Kourdish village of Gouaragatch, and for some time we found ourselves in quite a different element. These Kourds are purely agricultural, and belong to the *Jass* or race of wandering Kourds. Their women go about with uncovered faces; they are a fine, handsome race, dark hair, high complexion, and large noses; their faces are all tattooed, and their heads hung with all sorts of ornaments, cowrie beads and savage jewellery. The women wear large, baggy trousers, and heavy headdress, and a loose red dress. We were, with some difficulty, able to obtain photographs of some groups. The turban is the distinguishing feature of the male Kourd, no sheepskin hat or red cap being worn by them; the turban is made of chequered silk, red, yellow, and blue, with gold and silver thread. A Kourdish chief in travelling dress wears a light blue jacket, long flowing shirt-cuffs, and magnificent things in the way of daggers.

Everything here shows a tendency to superior art. Stone is introduced into the construction of the houses, a relief after the many mud villages we had passed through of the Afshah tribe. Red ornamentations made with henna adorn the doors and windows, and the construction of the compounds is interesting; by a low wicker gate you enter a courtyard, this gate being covered with dung cakes; an outer covered shed contains the tripod for hanging the skin on for making 'mast,' and the blacksmith's bellows, with double funnel, ornamented at the top and at the bottom, having feet formed like birds with beaks; the family rooms open into this shed; they are only lighted from the roof, and full of smoke, and have great store cupboards for grain, also made of dung and mud, and ornamented with rosettes and other patterns. There are many and elegantly-shaped waterpots, made of a clay found close to the village, where we found the women busily engaged in digging; any number of quaint-shaped copper utensils for boiling milk stood around a cauldron, and several dark, handsome women, with two dark tufts of hair

on either side of their faces and wearing round fezes bound to the head by red handkerchiefs, with noses pierced for silver solitaires, were busily engaged in preparing the evening meal.

The home-coming of the flocks at evening was interesting. At a given spot outside the village crowds of women and children were assembled at the hour appointed, and when the bleating was heard, each one rushed forward to seize his own, wildly screaming, and creating a perfect pandemonium of noises. Children of five were left in charge of two or three kids as large as themselves, for the Kourd begins early to make himself useful. The Kourds are nearly all Sonnee, and we were shown the village mosque and bath—a thing unknown in the districts of the Shiah faith.

On the following day we rode over a mountain-pass, with rich moorland scenery, amongst the mountains of Kourdestan, with acres of fennel growing where in England we should find bracken; a dervish is seated at the highest point begging alms, for many pilgrims pass over this road on their way to Kerbela. The ground gradually descends towards the level of lake Urmia, and we begin to pass encampments of nomads on their way to their summer quarters, the poorest of them being armed with guns and daggers, for this part of Kourdestan on the border of Azebeijan is exceedingly dangerous, and the scene of frequent feuds; blood-feuds are perpetual, which end in the extirpation of whole families, and there is no Government here to keep them in check. The tents of the nomads are black, of thick goat's hair, with tufts at the top, the walls are of matting, to allow of a current of air during the summer heats, before the tents boil cauldrons of milk, and there is always the tripod for making *mast* by vigorously shaking a skin suspended from the centre. As they travel their cavalcades are most amusing to watch—on one cow is strapped its lately born calf, another cow carries two or three kids, and perhaps the mother goat, who has just been confined, other cows carry the tents and poles, with men perched on the top: the donkey is laden with the household utensils, on the top of which are tied the cocks and hens. The women generally walk, and the young and active go before with the flocks; thus they march day after day till their summer quarters are reached, up in the vast mountain range of Sechend.

We arrived in the afternoon at another Kourdish village called Sinjate, favourably situated in a gorge, and surrounded by many Sinjate trees, from which presumably comes its name. The Sinjate or jujube tree is a common one in most of these villages; it resembles the olive in foliage, and its date-like fruit is a common means of sustenance amongst the inhabitants; it is sweet but very woolly and disagreeable to eat.

Here, again, many amusing scenes of Kourdish life were brought before our notice in our compound. We entered one room and found several women seated on their haunches around the heated *tanure* or oven, made of a large earthenware jar and stuck in the ground; it is heated with brushwood and connected by a flue with the outer air. At Sinjate the women wore an immense number of cowrie beads, their caps and aprons being trimmed with them, and even bracelets made of them. They were busy making bread after the following fashion:—One woman makes the dough into balls, the size of her fist, this she beats with her hand into flat cakes, about a ¼ inch thick and 10 inches across. This she hands to the chief bakeress, who presides over the *tanure*, and who, by some mysterious legerdemain, merely by throwing the cake from hand to hand,

expands it to a thin oval sheet, the thickness of paper; this she deposits on a very dirty pillow, one end of which is open to let in her hand; and thus poised she dashes it against the heated side of the *tanure*, and when baked to her satisfaction she removes it with two sticks.

The village of Sinjate is one vast expanse of mud-roofs, over which we could wander from end to end. The inhabitants were very civil in showing us their houses, and the women always greeted us as we passed by holding up their hands.

Just below Sinjate we joined a stream, which is the source of the Checkatoo, a considerable river flowing into the southern end of Lake Urmia, and after a few hours' ride along its banks we reached Sainkallà, a large village around a mud fort on a hill; this place acts as a sort of capital for the Afshah tribes, who frequent the neighbouring mountains, and here Haidar Khan holds his court during half the year, but unfortunately he was absent just then; however, we were comfortably lodged in his house and took the opportunity of resting for two days after our tedious journey through the mountains. Sainkallà boasts of a little bazaar, where we were able to obtain several much-needed commodities, but it is a most desolate spot, having been entirely ruined during the invasion of the Kourds a few years ago under Sheik Albidowleh; the wild tribes under his leadership overran most of this district and did irreparable harm. Siankallà from its position is a place of strategical importance, inasmuch as it commands the entrance into Eastern Kourdestan, by the way of the source of the Checkatoo down which we had come.

After leaving Sainkallà at the distance of a few miles we came across a very interesting place and an interesting tribe. This is Mahmoud-Jute, where Norooz Khan, the head of the Chehar-dowleh tribe lives in almost regal state.

The Chehar-dowleh is a small tribe, but has a great reputation for bravery; originally they came from the south of Persia but were transplanted to the neighbourhood of Kasvin by Fattiali Shah, the grandfather of the present sovereign; Mahmoud Shah, Nasr-ed-din's father, again transplanted them to the banks of the Checkatoo, and here they have flourished exceedingly.

Norooz Khan, their chief, was the only one in this neighbourhood who succeeded in keeping back the Kourds from his district, consequently his castle and village of Mahmoud-Jute was the only one we passed through in this district which did not show traces of the ravages of war. Here he lives, and may almost be said to be an independent sovereign, for though he wears the uniform of a Persian general yet he refuses to pay any taxes, refuses to go to Teheran, and exercises regal authority over his small kingdom. He received us graciously in his large palace, with a lovely reception-room or *talya* with a view over the rich valley of the Checkatoo and Kourdish mountains. Around the palace, which covers two acres or more with its buildings and gardens, runs a mud wall with innumerable bastions, on the top of each of which a stork has built its nest, as also they have done on every available vantage ground, so that the whole place is alive with these sacred birds—a sure sign of peace and prosperity.

Norooz Khan told us much about his tribe; he owns, he said, 2,000 houses, and he has about 5,000 reyet or dependents; his territory stretches from Sainkallà to Mianduwab, and his subjects are chiefly sedentary and engaged in tilling the fertile valley of the Checkatoo; though there are

several nomad families who dwell in the villages during the winter months and go up to the *yaëla* or mountain pasturages during the summer. The legend in the tribe is that once they beat a combined force of four other tribes and took the name of 'four governments,' Chehardowleh, but this I should imagine to be a fable; from their physique and also South Persian origin I should imagine the tribe to be of Arabian descent. Norooz Khan himself, with thick lips and stunted stature, might have some negro blood in his veins. His meal was excellent, served up for us on a table, whilst the others ate on the floor, and performed feats of wonderful dexterity in feeding themselves with their fingers. All around the palace are mud houses and underground abodes; there is also a bazaar, and a general air of prosperity about the place.

The banks of the Checkatoo, especially as Mianduwab is approached, are very fertile. At the village of Karyagdeh we first came across a wheeled vehicle consisting of a cart, a triangular plateau 15 feet long, at the apex of which buffaloes are fastened and the whole supported by an axle joining two wheels without spokes, in many instances plain, circular pieces of wood. For threshing corn they use a spiked cylinder attached to a pole which is drawn round and round by buffaloes, and acts the part of a flail. Buffaloes are here in constant use; they wallow and swim in the river, and naked urchins may be seen washing and scraping their backs to prevent a cutaneous disease to which these amphibious animals are very liable if not properly cared for. The valley of the Checkatoo produces tobacco in small quantities, corn, and castor-oil, this latter commodity being used here for lamps and all household purposes. In each village there is a large stone, generally an old gravestone, put up near the mosque, which is public property, and where women take their turn in bruising the castor-oil pods for their use. By the side of the river where there is no cultivation, we passed the tents of several nomads, waiting here with their flocks for the season to go up to the mountains. Before the tent of the chief stands the lance, the emblem of authority, reminding one forcibly of Saul (1 Sam. xxvi. 7) sleeping in his tent with his spear stuck in the ground at his bolster. The family here is the basis of society, the chief is the head of the family; they are strong, powerful individuals, capable under a good government of great development, and could Turkey or Persia ever reform its ruling classes, they would find the wandering tribes a new and powerful backbone to the nations.

By the banks of the Checkatoo, north of Mianduwab (which, by the way, means the place between two rivers, the Tatoo and the Checkatoo), there are many curious underground villages inhabited by the nomads in the extreme colds of winter, the thatched roofs of the houses alone appearing above ground; they reminded us forcibly of Xenophon's account of this part of the world, when returning with the 10,000 through the wild mountains of the Karduchi or Kurds. 'The houses are underground,' he says, 'the mouth resembling that of a well, but spacious below; there is an entrance dug for cattle, but the inhabitants descend by ladders.'

On crossing the Checkatoo by a boat shaped like half a barge, we came across a large plain running between the Seehend range and Lake Urmia. The inhabitants here are chiefly sedentary members of the Afshah tribe, with very fertile gardens around their villages; most of them keep pigeons for the dung, which is used in the production of melons and

other fruits, pigeon towers being almost as conspicuous objects here as they are in the neighbourhood of Ispahan. Kourdish ravages are everywhere visible in the shape of ruined villages and fields neglected. Before reaching the town of Binab we tarried to lunch in a mud fort erected by one Khaleel, in which the scattered inhabitants of a neighbouring ruined village are gradually collecting and making for themselves mud huts. They call the place Khaleelevan, and as for the traces of their old homes they will soon be obliterated.

A series of photographs has been prepared of types and local idiosyncrasies, and the Committee beg to request to be reappointed, and that a sum of 50*l.* be placed at their disposal.

Report of the Committee, consisting of Sir RAWSON RAWSON, Mr. G. W. BLOXAM, General PITT-RIVERS, Dr. J. BEDDOE, Dr. H. MUIRHEAD, Mr. C. ROBERTS, Dr. G. W. HAMBLETON, Mr. F. W. RUDLER, Mr. HORACE DARWIN, Dr. J. G. GARSON, *and* Dr. A. M. PATERSON, *appointed for the purpose of investigating the effects of different occupations and employments on the Physical Development of the Human Body.*

OWING to various circumstances the work of the Committee has been practically at a standstill during the past year, and the grant has not been drawn.

The Committee ask for reappointment and that the grant may be renewed.

Report of the Committee, consisting of General PITT-RIVERS, Dr. BEDDOE, Professor FLOWER, Mr. FRANCIS GALTON, Dr. E. B. TYLOR, *and* Dr. J. G. GARSON, *appointed for the purpose of editing a new Edition of 'Anthropological Notes and Queries.'* (*Drawn up by the Secretary*, Dr. GARSON.)

THE Committee have to report that the Anthropological Institute of Great Britain and Ireland readily undertook the work of editing the new edition of 'Anthropological Notes and Queries,' as was recommended in the last report of this Committee.

During the year considerable progress has been made, and the Committee have much pleasure in placing before the Association the proof-sheets of a large part of the new edition. The Editing Committee of the Institute hope to have the work completed and ready for publication during the course of the present year.

The Committee have not drawn any of the grant of 50*l.* placed at their disposal at the Bath meeting, but liabilities have been incurred for setting up in type that portion of the work now before the Association, which will require to be met during the ensuing year, and money will be required to meet the cost of printing the remaining portions now or about to be placed in the printer's hands. The Committee therefore seek to be reappointed, and to have the grant of 50*l.* from last year again placed at their disposal.

The Committee desire to render their best thanks to the Council of the

Anthropological Institute for the hearty response it made to the invitation to undertake the work, and for the efficient manner in which the duties undertaken have been discharged.

Report of the Corresponding Societies Committee, consisting of Mr. FRANCIS GALTON (*Chairman*), Professor A. W. WILLIAMSON, Sir DOUGLAS GALTON, Professor BOYD DAWKINS, Sir RAWSON RAWSON, Dr. J. G. GARSON, Dr. JOHN EVANS, Mr. J. HOPKINSON, Professor R. MELDOLA (*Secretary*), Professor T. G. BONNEY, Mr. W. WHITAKER, Mr. G. J. SYMONS, General PITT-RIVERS, *and* Mr. W. TOPLEY.

THE Corresponding Societies Committee of the British Association beg to report to the General Committee that the two meetings of the Conference of Delegates were held on Thursday, September 6, and Tuesday, September 11, 1888, at 3.30 P.M., in the Grammar School at Bath.

The following Delegates were nominated for the Bath meeting:—

Rev. H. H. Winwood, M.A., F.G.S.	Bath Natural History and Antiquarian Field Club.
Mr. Wm. Gray, M.R.I.A.	Belfast Naturalists' Field Club.
Mr. John Brown	Belfast Natural History and Philosophical Society.
Mr. Charles Pumphrey	Birmingham Natural History and Microscopical Society.
Mr. J. Kenward	Birmingham Philosophical Society.
Rev. T. Hincks, F.R.S.	Bristol Naturalists' Society.
Mr. H. T. Brown, F.G.S., F.C.S.	Burton-on-Trent Natural History and Archæological Society.
Mr. T. H. Thomas	Cardiff Naturalists' Society.
Rev. J. M. Mello, M.A., F.G.S.	Chesterfield and Midland Counties Institution of Engineers.
Mr. T. Cushing, F.R.A.S.	Croydon Microscopical and Natural History Club.
Mr. G. H. Bailey, D.Sc., Ph.D.	Cumberland and Westmorland Association for the Advancement of Literature and Science.
Mr. J. C. Mansell-Pleydell, J.P.	Dorset Natural History and Antiquarian Field Club.
Mr. A. S. Reid, M.A., F.G.S.	East Kent Natural History Society.
Mr. Robert Brown, R.N.	East of Scotland Union of Naturalists' Societies.
Mr. Ralph Richardson, F.R.S.E.	Geological Society of Edinburgh.
Prof. R. Meldola, F.R.S., F.C.S.	Essex Field Club.
Mr. D. Corse Glen, F.G.S.	Geological Society of Glasgow.
Prof. F. O. Bower, M.A., D.Sc.	Natural History Society of Glasgow.
Dr. H. Muirhead	Philosophical Society of Glasgow.
Mr. J. Hopkinson, F.L.S., F.G.S.	Hertfordshire Natural History Society and Field Club.
The Deemster Gill	Isle of Man Natural History and Antiquarian Society.
Mr. S. A. Adamson, F.G.S.	Leeds Geological Association.
Mr. G. F. Deacon, M.Inst.C.E.	Liverpool Engineering Society.
Mr. F. T. Mott, F.G.S.	Leicester Literary and Philosophical Society.
Mr. G. H. Morton, F.G.S.	Liverpool Geological Society.
Mr. Eli Sowerbutts, F.R.G.S.	Manchester Geographical Society.
Mr. Mark Stirrup, F.G.S.	Manchester Geological Society.

Mr. R. G. Durrant	Marlborough College Natural History Society.
Mr. E. B. Poulton, M.A., F.L.S.	Midland Union of Natural History Societies.
Prof. G. A. Lebour, M.A., F.G.S.	North of England Institute of Mining and Mechanical Engineers.
Dr. J. T. Arlidge, M.A. . . .	North Staffordshire Naturalists' Field Club.
Mr. C. A. Markham . . .	Northamptonshire Natural History Society and Field Club.
Mr. Matthew Blair, F.G.S. . .	Paisley Philosophical Institution.
Mr. Robert Brown, R.N. . .	Perthshire Society of Natural Science.
Mr. H. R. Mill, D.Sc. . . .	Royal Scottish Geographical Society.
Mr. W. Andrews	Warwickshire Naturalists' and Archæologists' Field Club.
Mr. J. W. Davis, F.G.S. . . .	Yorkshire Geological and Polytechnic Society.
Rev. E. P. Knubley, M.A. . .	Yorkshire Naturalists' Union.

At the first Conference the chair was taken by Dr. John Evans, the Corresponding Societies Committee being represented by General Pitt-Rivers, Sir Douglas Galton, Professor Boyd Dawkins, Professor T. G. Bonney, Mr. W. Whitaker, Mr. G. J. Symons, Mr. W. Topley, Dr. Garson, Mr. J. Hopkinson, Mr. W. White, and Professor R. Meldola (Secretary).

The Chairman moved that in order to save time the Report of the Corresponding Societies Committee to the General Committee, printed copies of which had been distributed among the Delegates, should be taken as read. This was put to the meeting and carried.

The Delegates were invited to make any statements respecting the work done by the Committees appointed last year, or in connection with other subjects referred to in the Report.

The Ancient Monuments Act.

A discussion with respect to the working of this Act took place, in the course of which Dr. Muirhead pointed out that a Bill was then before Parliament which, if passed, would place the bye-paths in Scotland under the control of a public officer, and he suggested that the ancient monuments might be dealt with in the same way. Dr. Mill stated that the Royal Scottish Geographical Society had appointed a sub-committee to take the matter into consideration.

The Deemster Gill said that the provisions of the Ancient Monuments Act did not apply to the Isle of Man, but it would doubtless interest the meeting to know that an Act had lately (1886) been passed by the Manx legislature somewhat, though not exactly, on the lines of the Imperial Act for the preservation of ancient monuments, of which there were many of great interest in the island. The Act was permissive only, and owners might place monuments under its protection either permanently or provisionally. The monuments which were thus protected were vested in seven trustees, three *ex officio* and four appointed by the Governor. These trustees resided in different parts of the island, and thus local interest was secured for the different localities. A copy of the Manx Act had been forwarded to the Secretary of the Conference.

Mr. Wm. Gray called attention to the desirability of drawing up correct lists of existing remains, and of having their positions registered on approved maps on a uniform plan and by means of some generally recog-

nised system of signs. He thought that the Delegates might see that such lists and maps were prepared for their own localities, the results being finally collected and transferred to one general map of the whole kingdom. The Belfast Naturalists' Field Club, which he represented, would be glad to assist in the work, and had already prepared maps and lists for the north of Ireland, which were only waiting for the approved set of signs.

Professor Boyd Dawkins alluded to the necessity of having the work done as rapidly as possible, and Mr. J. W. Davis pointed out that the International Archæological Congress, which met at Stockholm in 1874, had adopted a set of signs which had been published in the 'Comptes Rendus' of the Congress as well as in the 'Journal of the Anthropological Institute.' He thought that these signs might well be adopted and used on the one-inch ordnance map. Mr. F. T. Mott suggested that it would be an advantage if these signs could be reprinted and circulated among the local Societies willing to take part in the work.

The Chairman (Dr. Evans) stated that two distinct bodies were now at work upon this proposed catalogue of ancient remains, the British Association Committee, of which Mr. Davis was the secretary, and the Society of Antiquaries. The last-named Society proposed to summon a congress of Delegates from all the local Archæological Societies in the course of the year, with the object of promoting a complete archæological survey of the whole country. This, of course, need not interfere with the surveys by the local Societies. With respect to maps he remarked that a small scale, viz., $\frac{1}{4}$ inch to the mile, had been adopted in the 'Archæologia,' and in the course of the year a survey of Kent would appear in that publication.

General Pitt-Rivers, Inspector of Ancient Monuments, pointed out that the proposed archæological survey was quite distinct from the Ancient Monuments Act, the working of which he had fully explained in his address to the Anthropological Section.[1] After remarking that none of the local Societies had rendered any assistance in getting the landowners in their districts to place their monuments under the protection of the Act, the Inspector stated that these Societies were, in the present state of the law, in a better position to see to the preservation of their ancient monuments than any Government Inspector, and he urged upon the Delegates the necessity of recommending their respective Societies to take this duty upon themselves. The Bill as at first drafted was intended to have been compulsory, but in its present form it was only permissive. He did not think the Government should be made responsible for the preservation of all the ancient monuments, but he was decidedly of opinion that the Act should be modified, and that more authority should be given to the Inspector. As he had stated in his Presidential Address, he had obtained eleven new monuments during the year, but had been obliged to resign three because the Government would not consent to take them over.

Sir John Lubbock observed that as the Act was originally framed the proposal was as follows :—The monuments mentioned in the schedule to the Bill, and any others subsequently included in the list by the authority constituted, were declared to be ancient national monuments within the meaning of the Act. If, then, the owner of any such monument wished to destroy or mutilate it, he was bound before doing so to give notice to the proper authority, who then had three months to consider whether it

[1] *Report*, 1888, p. 825.

should be purchased for the purpose of being preserved. This would have enabled local authorities and local Societies to acquire such properties. The present Act was inoperative unless owners voluntarily placed their monuments under it. He (Sir John Lubbock) was glad to see that so many owners had done so, and he was surprised to hear that the Government had hesitated to accept any ancient monument. The expense was small, and he was sure that Parliament would not grudge the money. He thought it would be very desirable if local Societies would either induce the local authorities or would themselves take over the preservation of monuments in their own neighbourhood. They would thus be much more effectively preserved, and in that case it was probable that the numbers placed under the protection of the Act might be considerably and quickly increased. He was not sure whether this could not be done under the Act as it stands, but if not he should think it might be amended without much difficulty. At the same time he confessed he should like to go further. These monuments were of national interest, and he thought it was not too much to ask, as a general provision applying to all such remains, that the owner before destroying them should at least give the nation the opportunity of purchasing and preserving them.

Work of other Committees, and Suggestions.

Temperature Variation in Lakes, Rivers, and Estuaries.—Dr. H. R. Mill stated that the report of this Committee had been drawn up, and would be presented to Section A; he proposed to submit the result to the Delegates at the next Conference.

Earth Tremor Committee.—Professor Lebour reported that the Committee was about to apply for reappointment with the object of, in the first place, prosecuting inquiries as to the best form of instruments and the best conditions with respect to locality, foundation, &c., for fixing up such instruments. Several Societies and individuals had expressed their willingness to co-operate as soon as these conditions had been determined, and the Birmingham Philosophical Society had made a grant towards the expenses of these preliminary trials.

Professor Lebour stated also that the North of England Institute of Mining and Mechanical Engineers had recently appointed a Committee armed with a substantial grant to make a series of experiments on so-called 'Flameless Explosives.' This Committee was now at work, and would gladly receive assistance in any way from kindred Societies. The same Institute had joined with the Mining Institutes of South Wales and Scotland in forming another Committee to conduct a series of experiments on fan-ventilation. He thought that these were examples of the kind of co-operation which the Conference of Delegates of Corresponding Societies was likely to bring about.

At the second Conference the chair was first taken by the Secretary, Professor R. Meldola, and afterwards by the Vice-Chairman, Mr. W. Whitaker, the Committee being further represented by Mr. J. Hopkinson and Mr. W. White, and towards the close of the meeting by Dr. Evans, who had been detained at the Committee of Recommendations.

The Chairman in opening the proceedings said that it would be best to adopt their usual plan, and consider the suggestions and recommendations from the different Sections in their proper sequence.

Section A.

Temperature Variation in Lakes, Rivers, and Estuaries.—Dr. Mill said that he wished to point out some of the results that had been obtained by the Committee appointed to make the investigations in conjunction with the local Societies represented in the Association. He had a diagram which showed the work done more precisely than he could explain in a short time. The Committee had twenty observers working at various rivers; most of these rivers were in Scotland, only one or two being in England, while no observations had been started in Ireland. Their investigations showed that while in some rivers, particularly the Aray, the temperature was increased by rainfall, in others this condition was reversed, the temperature being found to suddenly fall during rain. He wished to impress upon the Delegates the advisability of extending their observations throughout Scotland and England, and also of extending them to Ireland. Professor Fitzgerald, the President of Section A, who was a member of the Committee, took a great interest in the subject, and had expressed an opinion that Mr. Symons's rain-gauge observers might make personal observations. Dr. Mill advised all observers to use the thermometer which he exhibited, and which he said was durable and cheap. He trusted that Delegates on returning home would lay the subject before their Societies, give them some idea of the work of the Committee, and induce them to co-operate and make observations in their respective localities. Circulars, he added, would be sent to the Societies and to Mr. Symons's rain-gauge observers, and it was hoped that this would bring the question well before them. It would give local Societies an opportunity of doing what they professed to do, and he was perfectly certain they were anxious to promote real scientific work. The observations could be made with very little training, and the investigations of conscientious observers would lead to interesting results, as they would be considered by the Committee in connection with the temperature and rainfall of the districts in which they were made.[1]

In reply to questions by Mr. Cushing and the Rev. E. P. Knubley, Dr. Mill said that the thermometer readings were taken at a depth of six inches below the surface of the water, and that the fullest particulars would be supplied by the Committee to any Society wishing to take part in the observations.

Section B.

No recommendations sent or suggestions made.

Section C.

Professor Lebour, who had been nominated as the representative of the Committee of this Section, said that the Committees on (1) Sea-Coast Erosion, (2) Underground Waters, (3) Erratic Blocks, and (4) Earth Tremors, the working of which had been explained to the Delegates on former occasions, had been recommended for reappointment.

Geological Photography.—Professor Lebour further informed the Delegates that in consequence of a paper read before Section C by Mr. O. W. Jeffs on local geological photographs, it was proposed by the Committee of the Section that a Committee should be appointed to collect and register such photographs. The proposal at present was so indefinite that there

[1] *Report*, 1888, p. 326.

was no chance of the Committee of Recommendations dealing with it that year, but they gave the suggestion their cordial sympathy, and it was formally passed on to the meeting of Delegates. It was hoped that Delegates of Corresponding Societies, by discussing the matter among themselves, would have it so organised and ready to place before the Committee of the Section next year, and ultimately before the Committee of Recommendations, in such a form that a Committee of the Association might be appointed, with a small grant, to work the scheme satisfactorily. It was thought by the Committee of the Section that too many restrictions as to the uniformity of the photographs should not be enforced in the early stages of the scheme. The simple collection and registration of photographs was all that was at present aimed at.

The following suggestions with reference to this subject were forwarded by the Committee of the Section to the Secretary of the Conference:—

'1. That a Committee be formed, having representatives for each county, charged with the arrangement of a local photographic survey for geological purposes in each district.

'2. The Committee will gather together—

(*a*) Names of Societies and individuals who have already assisted in this object, or who are willing to do so;
(*b*) Copies of geological photographs already taken;
(*c*) List of localities, sections of rocks, boulders, and other features desirable to be photographed;

and will arrange with local Societies for the work to be done as may be convenient or possible.

'3. Each photograph to be accompanied by the following particulars:—

(*a*) Name and position of locality or section;[1]
(*b*) Details of features shown (with illustrative diagram or sketch whenever necessary for such explanation);
(*c*) Scale of height and length, or figure introduced to indicate size in nature;
(*d*) Name of photographer and Society under whose direction the view is taken;
(*e*) Date when photographed.

'4. Size of photograph recommended: 12 in. × 10 in., but this is not compulsory.

'5. Original negative to be the property of the Society or individual under whose direction it is taken, and who shall also fix a price at which copies may be sold.

'6. One copy of each photograph to be the property of the British Association, and one other copy to be given to the Geological Society of London.

'7. Each photograph officially received to be numbered and recorded in a reference-book, and a list published and circulated showing price at which members and others may purchase them.

'8. A circular to be issued to all geological Societies inviting their co-operation.'

Mr. Jeffs said that a large number of Societies in different parts of the kingdom had taken from time to time photographs of various geological sections and features as they came under their notice, but there had been

[1] Including Compass Direction.—*Sec. Corr. Soc. Comm.*

no systematic way adopted either of collecting the photographs or of recording them, so that geologists interested might really know what had been taken. He thought that if some arrangement could be made, a great deal of good might be done, not only for the benefit of geological science, but also for educational purposes. Regarding regulations, he was not desirous of laying down any strict rules, but he thought that if the scheme were to be carried out at all satisfactorily and at a minimum expenditure, some few regulations would be necessary.

Mr. Whitaker thought it a very fit subject for the Conference, and trusted that Delegates would get their Societies to think it over. The object was to interest all the Societies and to have an harmonious result.

Some further discussion took place with reference to the requirements of the proposed Committee and the mode of procedure in the field, in the course of which it was pointed out that the chief object was to secure photographs of typical and especially of *temporary* sections. The details of manipulation, the size of the photographs, method of mounting, registration of scale, &c., could only be settled when the Corresponding Societies had taken action in the matter and the Committee had been formally appointed.

International Geological Congress.—Mr. Hopkinson called the attention of the Delegates to this Congress, which met in London last year, and pointed out the conditions under which Societies could get the volume of Proceedings. He suggested that every Society which intended to publish geological maps should ascertain the rules as to nomenclature and colouring adopted by the Congress, so that some degree of uniformity might be arrived at.

Section D.

The Committee of this Section was represented by Professor Hillhouse.

Life-histories of Native Plants.—Professor Meldola said that since their last meeting at Manchester, Professor Bayley Balfour had received several applications for further particulars with reference to the suggestion which he communicated to the previous Conference. Professor Balfour was unable to be present at Bath, but had forwarded the following:—

'*Suggestions for those studying the Life-histories of British Flowering Plants*:—

'1. Seeds should be collected, and opportunity may be taken at the time of collection to note how they are disseminated in nature—whether the fruit opens or not, whether they have appendages for promoting transport by animals or otherwise, whether they have colour or other features of attraction, &c.

'2. The seeds being sown, their germination should be watched; its rapidity and manner noted. The variations and differences between albuminous and exalbuminous seeds are worthy of special note. The movements of the parts of the embryo in germination until it acquires its fixed position are also deserving of study. Further, the form of the parts of the embryo is various and instructive.

'3. The development of the seedling into the adult can be readily watched in annuals and biennials and smaller perennials. The succession of leaves after the cotyledons should be noted, and the forms which the leaves assume and their positions and spread. The relative succession of buds in or adjacent to the axils of the later leaves and of the cotyledons

should be observed, as also the ultimate fate of the buds developed. This will give a clue to the branching of the main axis of the plant, upon which its whole form and habit depend.

'4. An important point to look at in the development is the amount, character, and position of any clothing of hairs the seedling may possess.

'5. The development of the underground part of the seedling must not be neglected. The continuance of the primary root and its branching or its replacement by adventitious roots are points for particular attention, and also the formation upon it of any excrescences or buds. A sufficient number of seedlings must be grown to allow of proper study of these features.

'6. The form of branching of the stem and leaves may be studied in the mature plant, which may be gathered wild. The formation of false axes should be specially looked for, and the complex relations often resulting from branching may be worked out upon the young top of a mature plant. It is not necessary to wait for the maturing of the seedling, but reference back to the seedling will show whether any observed relations are of late or early development in the life-history.

'7. In the case of perennials, the mode of perennation is an interesting feature for observation, as well as the methods of vegetative propagation. In some cases the two processes are merged in one. Properly to understand perennation the perennating portions must be examined at all periods of the resting season as well as when they are starting anew into vegetative activity. Seedlings of perennating plants watched during two or three seasons will give a clue towards elucidation of the development.

'8. When the seedlings begin to form flowers the relation of the flower-shoots to the vegetative organs should be noted, and especially their sequence with reference to vegetative shoots. The succession of the flowers should be noted, as of course should be their structure and their adaptations to proper pollination. Many seedlings will not, of course, flower for years, and the sequence of flowers in such plants, and, indeed, in all cases, may be well traced in the mature plant growing wild.

'9. After flowering and pollination the development of fruit must be studied. The parts concerned in forming fruit, the adaptations to scattering of the fruit or seed are points to be precisely noted.

'10. The presence and position of any nectar-secreting structures outside as well as inside the flower are of much significance, and they should be carefully studied.

'11. In connection with every point observed of structure and development, the observer should ask himself, Why is this? What is this for? and endeavour to obtain some answer to the query.

'12. A series of observations upon a specific plant made by a careful observer will enable him or her to draw up a complete history of its life, such as is hardly to be found recorded at the present day.

'I may add as a corollary that an interesting field for observation which local Societies might do good work in is that of the relation of plants to animals as food plants. Some are discarded by browsing animals, others are preferred, and there are degrees of favouritism. Is there any principle of selection?'

Professor F. O. Bower, the Delegate from the Natural History Society of Glasgow, who was unable to be present at the meeting, forwarded the following communication with reference to this subject:—

'While heartily endorsing Dr. Balfour's proposal that local Societies should turn their attention more directly to the study of the life-histories of plants rather than to mere record of new or rare forms, I fear that a direct diversion of the current of work into this direction will have its dangers, which the Societies must be prepared to meet at the outset. Of these the chief would be that in concentrating attention on the life-history the true identification of the species might be overlooked, and so observations, otherwise of great value, might be worse than useless. This danger would not be serious in the case of experienced members, who would merely extend with further detail their present observations on species which they already know; the danger is rather in the case of younger members, from whom the greater amount of work is to be expected. Unless there were some method of supervision there would be danger of observations on imperfectly identified plants being recorded. That even experienced botanists may make mistakes of identity of plants is shown by a case quoted in his address by the President of Section D, and this will serve to indicate that caution as to the true identity of the plants in question is imperative. I should suggest, therefore, in order to avoid such mistakes, that before any Society proceeded to publish observations, the identity of species to which the observations refer be carefully verified by a committee of experienced members, specimens being in all cases sent in with the drawings and descriptions; these should be preserved as a guarantee of identity of the species in question. In the cases of critical species a reference of the specimens to some known specialist on that genus would certainly enhance the value of the observations. This may at the outset appear a needless waste of trouble, but I would urge that the value of such observations as those suggested in Dr. Balfour's admirably drawn-up schedule will depend greatly upon the true recognition of the plants concerned, while even a very few mistakes would cause a want of confidence in the whole scheme. I even think that a central registration of the results would be an advantage, so as to prevent disappointment by duplicate observation of the same plants, but the drawing together of so many independent and scattered Societies into one system would probably present too many difficulties for practical working. I have every wish for the success of the line of work suggested by Dr. Balfour.'

Disappearances of Native Plants.—Professor Hillhouse said that he was in charge of a Committee appointed two years ago for the purpose of collecting information as to the disappearance of native plants from their local habitats. Their report for 1887 said the Committee intended presenting a report in 1888 concerning its inquiries in Scotland. He came to that meeting prepared with a report, and learnt to his surprise that the Committee had lapsed, but an application had been made to the Committee of Section D to have it reappointed. He gave some brief account of their work in the past year. The report for Scotland covered 85 flowers which were extinct, or were 'practically extinct,' and these were of the most varied kinds. It had been discovered that *Nymphæa alba* (the white water-lily) had been almost exterminated in the lochs about Dumfries; the name of the person who had committed the ravages upon it was brought before the local Natural History Society, an appeal was made to the proprietors of the lochs, and the individual was warned off estates in the neighbourhood on pain of prosecution for trespass. There was one plant that had only a single station in Scotland, *Scheuchzeria palustris*, which was found in the

Bog of Methven, and it had been destroyed in all probability by 300 or 400 black gulls settling in the bog and devouring everything in the shape of vegetation. Another plant which had been completely exterminated was one known as *Mertensia maritima*, which grew in shingle on the Bay of Nigg, and which had been destroyed by the shingle having been used to make concrete blocks to be used in the construction of a pier near at hand. Then a grass which grew in a patch near the Moray Frith had been destroyed by the overturning of a tree, which caused a large hole into which all the moisture of the patch drained; this grass was *Melica uniflora*. The Committee found that the disappearance of plants was caused in a great measure by the injudiciousness of individual botanists, and also by botanical exchanging clubs who held out inducements for the collection of 80 or 100 specimens of extremely rare varieties. The Committee hoped to present a report the following year.

No recommendations or suggestions were made from the other Sections. Under Section H, Mr. Gray expressed a hope that some means would be taken to circulate the approved signs for the registration of prehistoric remains on the maps.

Societies not enrolled as Corresponding Societies.

Mr. White submitted a list of Societies which he suggested should become associated with the British Association. They were, of course, Societies which published papers and did local work. He thought that every county should be in some way represented at the meetings of the Conference of Delegates. In the list he had included only one or two antiquarian or archæological Societies because these published papers on prehistoric remains, which was probably the limit which ought to be drawn in that direction.

The Secretary pointed out that this could not be considered as an official invitation to the outstanding Societies to become affiliated with the British Association, as their Committee had no power to issue such an invitation; but, having considered the list prepared by Mr. White, he (the Secretary) felt no doubt that most if not all the Societies mentioned therein would be admitted if application were made to the Committee in the usual way. Professor Meldola thought the Delegates might do good by calling the attention of the Societies in their own counties to the advantages arising from a general co-operation of all the *working* local Scientific Societies in the United Kingdom.

At the conclusion of the Conference votes of thanks were passed to the Chairman and Secretary.

The Corresponding Societies Committee have received applications for retention from all the Societies on the list, and they recommend that the General Committee should sanction their retention. The Corresponding Societies Committee have also received and considered applications from six new Societies, and they recommend that four of these, viz.: the Hampshire Field Club, the Malton Field Naturalists' and Scientific Society, the Rochdale Literary and Scientific Society, and the Woolhope Naturalists' Field Club, should be enrolled as Corresponding Societies of the British Association.

The Corresponding Societies of the British Association for 1888–89.

Full Title and Date of Foundation	Abbreviated Title	Head-quarters or Name and Address of Secretary	No. of Members	Entrance Fee	Annual Subscription	Title and Frequency of Issue of Publications
Barnsley Naturalists' Society, 1867	Barnsley Nat. Soc.	Public Hall, Barnsley. H. Wade, 10 Pitt Street	70	None	6*s.* and 10*s.* 6*d*	Transactions, occasionally.
Bath Natural History and Antiquarian Field Club, 1855	Bath N. H. A. F. C.	Rev. H. H. Winwood, Royal Literary and Scientific Institution, Bath	87	5*s.*	10*s.*	Proceedings, annually.
Bedfordshire Archæological and Natural History Society, 1887	Beds. A. N. H. Soc.	F. A. Blaydes and F. B. W. Phillips, M.A., Harpur Place, Bedford	60	None	7*s.* 6*d.*	Transactions, occasionally.
Belfast Natural History and Philosophical Society, 1821	Belfast N. H. Phil. Soc.	Museum, College Square. R. M. Young, B.A.	Shrhldrs, 199 Members, 42 Hon. Assoc., 6	7*l.* per Share None	Varies 1*l.* 1*s.*	Report and Proceedings, annually.
Belfast Naturalists' Field Club, 1853	Belfast Nat. F. C.	William Swanston, F.G.S., 50 King Street, Belfast	290	None	5*s.*	Report and Proceedings, annually.
Birmingham Natural History and Microscopical Society, 1864	Birm. N. H. M. Soc.	William P. Marshall, Mason College, Birmingham	201	None	1*l.* 1*s.*	'Midland Naturalist,' Monthly.
Birmingham Philosophical Society	Birm. Phil. Soc.	B. C. A. Windle, Medical Institute, Birmingham	120	None	1*l.* 1*s.*	Proceedings, annually.
Bristol Naturalists' Society, 1862	Bristol Nat. Soc.	University College, Bristol. Professor Adolph Leipner, 47 Hampton Park, Redland, Bristol	208	5*s.*	10*s.*	Proceedings, annually.
Burton-on-Trent Natural History and Archæological Society, 1876	Burt. N. H. Arch. Soc.	46 High Street. G. Harris Morris, Ph.D., F.I.C., Avondale, Alexandra Road, Burton-on-Trent	167	None	5*s.*	Annual Report. Transactions occasionally.
Cardiff Naturalists' Society, 1867	Cardiff Nat. Soc.	R. W. Atkinson, B.Sc., F.I.C., 44 Loudoun Square, Cardiff	416	None	10*s.*	Report and Transactions, half-yearly
Chester Society of Natural Science, 1871	Chester Soc. Nat. Sci.	Grosvenor Museum, Chester. G. R. Griffith and W. H. Okell	625	None	5*s.*	Annual Report. Transactions every three or four years.
Chesterfield and Midland Counties Institution of Engineers, 1871	Chesterf. Mid. Count. Inst.	Stephenson Memorial Hall. W. F. Howard, 13 Cavendish Street, Chesterfield	263	1*l.* 1*s.*	Members 31*s.* 6*d.*; Subscribers 21*s.*; Associates and Students 20*s.*	Transactions, quarterly.
Cornwall, Mining Association and Institute of, 1884	Cornw. Min. Assoc. Inst.	William Thomas, C.E., F.G.S., Tuckingmill, Camborne	350	None	Minimum, 10*s.* 6*d.*	Transactions, annually.
Cornwall, Royal Geological Society of, 1814	Cornw. R. Geol. Soc.	G. B. Millett, Penzance	100, and 16 Associates	None	1*l.* 1*s.*	Report and Transactions, annually.
Croydon Microscopical and Natural History Club, 1870	Croydon M. N. H. C.	W. Low Sarjeant, 7 Belgrave Road, South Norwood, S.E.	294	None	10*s.*	Proceedings and Transactions, annually.
Cumberland and Westmorland Association for the Advancement of Literature and Science, 1876	Cumb. West. Assoc.	J. B. Bailey, 28 Eaglesfield Street, Maryport	910	None	5*s.*	Transactions, annually.

SELECTED LIST OF SOCIETIES, &c. (*continued*).

Full Title and Date of Foundation	Abbreviated Title	Head-quarters or Name and Address of Secretary	No. of Members	Entrance Fee	Annual Subscription	Title and Frequency of Issue of Publications
Dorset Natural History and Antiquarian Field Club, 1875	Dorset N. H. A. F. C.	M. G. Stuart, New University Club, St. James's Street, London, S.W.	200	None	10*s.*	Proceedings, annually.
Dumfriesshire and Galloway Natural History and Antiquarian Society, 1876	Dum. Gal. N. H. A. Soc.	Dumfries. E. J. Chinnock, The Academy, Dumfries	213	2*s.* 6*d.*	2*s.* 6*d.*	Transactions and Journal of Proceedings, occasionally.
East Kent Natural History Society, 1858	E. Kent N. H. Soc.	Frank Baker, Canterbury	75	None	10*s.*	Transactions, occasionally.
East of Scotland Union of Naturalists' Societies, 1884	E. Scot. Union	William D. Sang, 12 Townsend Crescent, Kirkcaldy, N.B.	11 Societies, 1,053 Membs.	None	Assessment of 4*d.* per member	Proceedings, annually.
Edinburgh Geological Society, 1834	Edinb. Geol. Soc.	H. M. Cadell, 5 St. Andrew Square, Edinburgh	234	10*s.* 6*d.*	12*s.* 6*d.*	Transactions, annually.
Essex Field Club, 1880	Essex F. C.	William Cole, 7 Knighton Villas, Buckhurst Hill, Essex	400	10*s.* 6*d.*	10*s.* 6*d.*	'Essex Naturalist,' quarterly.
Glasgow, Geological Society of, 1858	Glasgow Geol. Soc.	J. B. Murdoch, Capelrig, Mearns, Glasgow	250	None	10*s.*	Transactions, annually.
Glasgow, Natural History Society of, 1851	Glasgow N. H. Soc.	D. A. Boyd and J. Trotter, 207 Bath Street, Glasgow	377	7*s.* 6*d.*	7*s.* 6*d.*	Proceedings and Transactions, annually.
Glasgow, Philosophical Society of, 1802	Glasgow Phil. Soc.	John Mayer, 207 Bath Street, Glasgow	642	1*l.* 1*s.*	1*l.* 1*s.*	Proceedings, annually.
Hampshire Field Club, 1885	Hants. F. C.	Hartley Institution, Southampton. T. W. Shore and W. Dale	200	None	5*s.*	Proceedings, annually.
Hertfordshire Natural History Society and Field Club, 1875	Herts N. H. Soc.	Dr. J. Morrison, F.G.S., Victoria Street, St. Albans	252	10*s.*	10*s.*	Transactions, quarterly.
Holmesdale Natural History Club, 1857	Holmesdale N. H. C.	A. J. Crosfield, Carr End, Reigate	78	10*s.*	10*s.*	Proceedings, usually every two years.
Inverness Scientific Society and Field Club, 1875	Inverness Sci. Soc.	Thomas Wallace, High School, Inverness	146	None	5*s.*	Transactions, occasionally.
Ireland, Royal Geological Society of, 1831	R. Geol. Soc. Ireland	Prof. W. J. Sollas, F.R.S., Trinity College, Dublin	140	None	1*l.* 1*s.*	Journal, generally annually.
Ireland, Statistical and Social Inquiry Society of, 1847	Stat. Soc. Ireland	Prof. C. F. Bastable, 35 Molesworth Street, Dublin	150	None	1*l.*	Journal, annually.
Leeds Geological Association, 1874	Leeds Geol. Assoc.	S. A. Adamson, F.G.S., 52 Well Close Terrace, Leeds	114	None	5*s.*	Transactions, annually.
Leicester Literary and Philosophical Society, 1837	Leicester Lit. Phil. Soc.	C. J. Billson, M.A., St. John's Lodge, Clarendon Park Road, Leicester	348	None	Members 1*l.* 1*s.*; Associates 10*s.* 6*d.*	Transactions, quarterly.
Liverpool Engineering Society, 1875	Liv'pool E. Soc.	Royal Institution. J. H. T. Turner, 3 Cook Street, Liverpool	180	None	1*l.* 1*s.*	Transactions, annually.
Liverpool Geological Society, 1858	Liv'pool Geol. Soc.	Royal Institution. W. Hewitt, B.Sc.	58	None	1*l.* 1*s.*	Proceedings, annually.
Liverpool, Literary and Philosophical Society of, 1812	Liv'pool Lit. Phil. Soc.	Royal Institution. John Rutherford, LL.B., Wason Chambers, 4 Harrington Street, Liverpool	271	10*s.* 6*d.*	1*l.* 1*s.*	Proceedings, annually.

Liverpool Microscopical Society, 1868	Liv'pool Mic. Soc.	Royal Institution. T. W. Bruce, 27 Wapping, Liverpool	133	10*s.* 6*d.*	10*s.* 6*d.*	Report, annually; Transactions, occasionally
Malton Field Naturalists' and Scientific Society, 1879	Malton F. N. Sci. Soc.	Thomas J. Blanche, Malton, Yorkshire	95	None	2*s.* 6*d.* and 5*s.*	Report, every two years.
Man, Isle of, Natural History and Antiquarian Society, 1879	I. of Man N. H. A. Soc.	P. M C. Kermode, Seabridge Cottage, Ramsey, Isle of Man	120	2*s.* 6*d.*	Gentlemen 6*s.* Ladies 3*s.*	Yn Lioar Manninagh; quarterly
Manchester Geographical Society, 1885	Manch. Geog. Soc.	Eli Sowerbutts, F.R.G.S., 44 Brown Street, Manchester	700	None	Ordinary 1*l.* 1*s.* Associates 10*s.* 6*d.*	Journal, quarterly.
Manchester Geological Society, 1838	Manch. Geol. Soc.	Mark Stirrup, F.G.S., 36 George Street, Manchester	214	None	1*l.*	Transactions; about nine parts per annum.
Manchester Statistical Society, 1833	Manch. Stat. Soc.	Francis E. M. Beardsall, 25 Booth Street, Manchester	Ordinary 184	10*s.* 6*d.*	10*s.* 6*d.*	Transactions, annually.
Marlborough College Natural History Society, 1864	Marlb. Coll. N. H. Soc.	Marlborough College. E. Meyrick.	160	1*s.* 6*d.*	3*s.*	Report, annually.
Midland Union of Natural History Societies, 1877	Mid. Union	Thomas H. Waller, 71 Gough Road, Birmingham	2,000	—	—	'Midland Naturalist,' monthly.
North of England Institute of Mining and Mechanical Engineers, 1852	N. Eng. Inst.	Prof. G. A. Lebour, Neville Hall, Newcastle-on-Tyne	730	None	21*s.*, 42*s.*, 63*s.*	Transactions, about every two months.
North Staffordshire Naturalists' Field Club and Archæological Society, 1865	N. Staff. N. F. C. A. Soc.	Rev. T. W. Daltry, M.A., Madeley Vicarage, Newcastle, Staffs.	401	5*s.*	5*s.*	Report and Transactions, annually.
Northamptonshire Natural History Society and Field Club, 1876	N'ton. N. H. Soc.	The Museum, Guildhall Road, Northampton. H. N. Dixon	200	None	10*s.*	Journal, quarterly.
Nottingham Naturalists' Society, 1852	Nott. Nat. Soc.	W. Handley Kay, Gresham Chambers, Beastmarket Hill, Nottingham	Honorary 8, Ordinary 150 Corresponding 10	None None None	None 5*s.* 2*s.* 6*d.*	Transactions and Report, annually.
Paisley Philosophical Institution, 1808	Paisley Phil. Inst.	J. Gardner, 3 County Place, Paisley	302	5*s.*	Members 7*s.* 6*d.*	Report, annually.
Penzance Natural History and Antiquarian Society, 1839	Penz. N. H. A. Soc.	G. F. Tregelles, Devon and Cornwall Bank, Penzance	93	None	10*s.* 6*d.*	Report and Transactions, annually.
Perthshire Society of Natural Science, 1867	Perths. Soc. N. Sci.	Tay Street, Perth. S. T. Ellison	309	2*s.* 6*d.*	5*s.* 6*d.*	Transactions and Proceedings, annually.
Rochester Naturalists' Club, 1878	Rochester N. C.	John Hepworth, Union Street, Rochester	110	None	5*s.* or 10*s.*	'Rochester Naturalist,' quarterly.
Rochdale Literary and Scientific Society, 1878	Rochdale Lit. Sci. Soc.	J. Reginald Ashworth, 20 King Street South, Rochdale	221	None	5*s.*	Transactions, occasionally.
Royal Scottish Geographical Society, 1884	R. Scot. Geog. Soc.	80A Princes Street, Edinburgh. A. Silva White	1,162	None	1*l.* 1*s.*	'Scottish Geographical Magazine,' monthly.
South African Philosophical Society, 1877	S. African Phil. Soc.	David Gill, F.R.S., Royal Observatory, Cape Town	72	None	2*l.*	Transactions, annually.
Warwickshire Naturalists' and Archæologists' Field Club, 1854	Warw. N. A. F. C.	W. G. Fretton, F.S.A., 88 Little Park Street, Coventry	70	2*s.* 6*d.*	5*s.*	Proceedings, annually.
Woolhope Naturalists' Field Club, 1851	Woolhope N. F. C.	H. Cecil Moore, Hereford	About 200	10*s.*	10*s.*	Transactions, annually.
Yorkshire Geological and Polytechnic Society, 1837	Yorks. Geol. Poly. Soc.	James W. Davis, F.G.S., Chevinedge, Halifax	240	None	13*s.*	Proceedings, annually.
Yorkshire Naturalists' Union, 1861	Yorks. Nat. Union	W. Denison Roebuck, Sunny Bank, Leeds; and Rev. E. P. Knubley Staveley Rectory, Leeds	375 and 2,109 Associates	None	10*s.* 6*d.*	Transactions, annually; 'The Naturalist,' monthly.

Index of the more important Papers, and especially those referring to Local Scientific Investigations, published by the above-named Societies during the year ending June 1, 1889.

⁂ This catalogue contains only the titles of papers published in the volumes or parts of the publications of the Corresponding Societies sent to the Secretary of the Committee in accordance with Rule 2.

Section A.—Mathematical and Physical Science.

Name of Author	Title of Paper	Abbreviated Title of Society	Title of Publication	Volume or Part	Page	Published
Baker, J. G.	North Yorkshire: Studies of its Botany, Geology, Climate, and Physical Geography (second instalment). Second Edition	Yorks. Nat. Union	*Trans.*	3	49	1889
Bedford, E. J.	Some Facts in Meteorology	Nott. Nat. Soc.	"	For 1888	42	"
Black, Surg.-Maj. W. G.	The Meteorology and Climate of Suez before and after the Opening of the Suez Canal	Manch. Geog. Soc.	*Journal*	4	249	"
Brown, A. J.	Cyclones	Burt. N. H. A. Soc.	*Trans.*	I.	139	"
Burder, Dr. G. F.	Rainfall at Clifton in 1887	Bristol Nat. Soc.	*Proc.*	V.	266	1888
" "	The Illumination of the Eclipsed Moon	" "	"	"	355	"
Dixon, H. N.	Phenological Observations in 1887	N'ton. N. H. Soc.	*Journal*	5	130	"
Evans, F. G.	The Meteorology and Kindred Phenomena of 1888	Cardiff Nat. Soc.	*Report and Trans.*	XX.	78	1889
Fordham, H. G.	On the Meteorite of the 20th of November, 1887	Herts N. H. Soc.	*Trans.*	V.	33	1888
Gavey, J.	On Multiplex Telegraphy	Cardiff Nat. Soc.	*Report and Trans.*	XX.	116	1889
Gibbs, T.	The Influence of Temperature on the Progress of Vegetation in the early Months of the Year	Burt. N. H. A. Soc.	*Trans.*	I.	80	"
Grensted, Rev. F. F.	A Theory to account for the Airless and Waterless Condition of the Moon	Liv'pool Geol. Soc.	*Proc.*	V.	335	1888
Henderson, Rev. A.	Meteorological Observations taken at Coats Observatory, Paisley	Paisley Phil. Inst.	"	1	16	1889
Hopkinson, J.	Report on the Rainfall in Hertfordshire in 1887	Herts N. H. Soc.	*Trans.*	V.	155	"
Jones, J. V.	A new Method of Measuring Rate of Rotation	Cardiff Nat. Soc.	*Report and Trans.*	XX.	30	1888
Law, F.	Meteorological Reports	N'ton. N. H. Soc.	*Journal*	5	25, 37, 125, 142	"
Lebour, Prof. G. A.	Barometer and Thermometer Readings for 1887 (with reference to Explosions in Mines)	N. Eng. Inst.	*Trans.*	37	261	—

McLandsborough, J., and A. E. Preston	Meteorological Tables	Yorks. Geol. Poly. Soc.	*Proc.*	XI.	137	1889
Morris, Dr. G. H.	Notes on Photo-micrography	Burt. N. H. A. Soc.	*Trans.*	I.	8	"
Morrison, W.	The Spectroscope	Inverness Sci. Soc.	"	II.	259	—
Petrie, Miss A. S.	The Eclipse of the Moon, Jan. 28, 1888	Rochdale Lit. Sci. Soc.	"	I.	117	1888
Poynting, Prof. J. H.	The Foundations of our Belief in the Indestructibility of Matter and the Conservation of Energy	Birm. N. H. M. Soc.	*Mid. Naturalist*	12	6	1889
" "	On a Form of Solenoid Galvanometer	Birm. Phil. Soc.	*Proc.*	VI.	162	—
Poynting, Prof. J. H., and E. F. J. Love	Note in correction of a Paper 'On the Law of the Propagation of Light'	" "	"	"	168	—
Rintoul, D.	Meteorological Observations, as regards Temperature, taken at Clifton, 1887	Bristol Nat. Soc.	"	V.	269	1888
Robinson, H.	A Review of the Progress of Natural Science n Belfast	Belfast Nat. F. C.	*Report and Proc.*	III.	24	—
Sharpe, D. R.	The Great Flood in Essex of August 1 and 2, 1888	Essex F. C.	*Essex Naturalist*	II.	199	1888
Thompson, I. C.	Presidential Address	Liv'pool Mic. Soc.	*Report and Trans.*	1	1	1889
Tyndall, W. H.	Meteorological Notes for 1885	Holmesdale N. H. C.	*Proc.*	For 1886–7	5	1888
" "	Meteorological Notes for 1886	" "	"	"	57	"
Watts, W.	Rains, Springs, and Rivers	Rochdale Lit. Sci. Soc.	*Trans.*	I.	50	"
Wells, J. G.	Notes on the Weather of 1887	Burt. N. H. A. Soc.	*Report*	Twelfth	26	"
Whitmill, C. T.	The Relation of Optics to Painting	Cardiff Nat. Soc.	*Report and Trans.*	XX.	62	1889
Wragge, C. L.	Cyclones and Anti-Cyclones	Inverness Sci. Soc.	*Trans.*	II.	289	—

Section B.—Chemical Science.

Atkinson, R. W.	Is Solution a Chemical or a Physical Process?	Cardiff Nat. Soc.	*Report and Trans.*	XX.	114	1889
Bedson, Prof. P. P.	A Contribution to our Knowledge of Coal Dust	N. Eng. Inst.	*Trans.*	37	245	—
Brierley, J.	Analysis of Water from a Pond	Hants. F. C.	*Proc.*	2	70	—
Brown, W., and Prof. Bedson	Explosion of an Air Receiver at Ryhope Colliery	N. Eng. Inst.	*Trans.*	37	197	—
Foster, Dr. C. Le Neve	On Testing Impure Air	Cornw. Min. Assoc. Inst.	"	II.	—	—
Francis, E.	The Examination of Potable Water for Micro-Organisms	Nott. Nat. Soc.	"	For 1888	20	1889

Section B.—CHEMICAL SCIENCE (*continued*).

Name of Author	Title of Paper	Abbreviated Title of Society	Title of Publication	Volume or Part	Page	Published
Heywood, H.	On an Artificial Mineral from the Brickwork of a Blast Furnace	Cardiff Nat. Soc.	*Report and Trans.*	XX.	116	1889
Morrison, W.	On Chemistry	Inverness Sci. Soc.	*Trans.*	II.	34	—
Ramsay, Prof. W., & Prof. S. Young	Researches on Evaporation and Dissociation	Bristol Nat. Soc.	*Proc.*	V.	298	1888
Tate, A. N.	On the Colouring Matter of the Mineral 'Blue John'	Liv'pool Geol. Soc.	"	V.	384	"
Thompson, Dr. C. M.	On the Classification and Nature of the Chemical Elements	Cardiff Nat. Soc.	*Report and Trans.*	XX.	21	"
Waller, T. H.	Micro-Chemical Methods for the Examination of Minerals	Birm. N. H. M. Soc.	*Mid. Naturalist*	12	59	1889

Section C.—GEOLOGY.

Name of Author	Title of Paper	Abbreviated Title of Society	Title of Publication	Volume or Part	Page	Published
Adamson, S. A.	Reports of Field Excursions in 1888	Leeds Geol. Assoc.	*Trans.*	IV.	206	1889
" "	The Yorkshire Boulder Committee and its Second Year's Work	Yorks. Nat. Union	*The Naturalist*	For 1888	332	1888
Adamson, S. A., and A. Harker	Geological Bibliography for North of England for 1886	" "	" "	"	178	"
" "	Geological and Palæontological Bibliography for 1887	" "	" "	For 1889	61	1889
Aitken, Dr.	Formation of Granite	Inverness Sci. Soc.	*Trans.*	II.	1	—
Baker, J. G.	North Yorkshire: Studies of its Botany, Geology, Climate, and Physical Geography (second instalment). Second Edition	Yorks. Nat. Union	"	3	49	1889
Balderston, R. R.	Evidences of Glacial Action near Ingleton	" "	*The Naturalist*	For 1888	189	1888
" "	The Succession of the Silurian Rocks of Ingleton and the included Trap-dykes of most interest	" "	" "	For 1889	131	1889
Beasley, H. C.	Some irregularly striated joints in the Keuper Sandstone of Lingdale Quarry	Liv'pool Geol. Soc.	*Proc.*	V.	386	1888
Bedford, J. E.	Notes on the Isle of Man	Leeds Geol. Assoc.	*Trans.*	IV.	177	1889
" "	The Oil-fields of America and Russia	" "	"	"	187	"

Bell, W. H.	On Geognosy of the Cruachan District	Edinb. Geol. Soc.	,,	V.	513	1888
Binnie, W. J. E.	The Mesozoic Rocks of the North-east Coast of Ireland	Yorks. Geol. Poly. Soc.	*Proc.*	XI.	53	1889
Bird, C.	The Krakatoa Eruption	Rochester N. C.	*Roch. Naturalist*	1	397	,,
Bird, W. J.	The South Durham Salt Bed and associated Strata	Manch. Geol. Soc.	*Trans.*	XIX.	564	1888
,, ,,	Notes on Seaton Carew Boring	N. Eng. Inst.	,,	38	21	—
Blair, M.	The Surface Geology of Paisley	Paisley Phil. Inst.	*Proc.*	1	11	1889
Bolton, H.	On Fish Remains from the Lower Coal Measures of Lancashire	Manch. Geol. Soc.	*Trans.*	XX.	215	,,
Bramwell, H.	Notes on the Horizon of the Lou Main Seam in a portion of the Durham Coal-field	N. Eng. Inst.	,,	37	151	—
Brown, H. T.	Notes on the Geology of the Hartshorne, Ticknall, and Melbourne District	Burt. N. H. Arch. Soc.	*Report*	Twelfth	21	1888
,, ,,	Notes on the Geology of the Milton, Ingleby, and Knowle Hills' District	,, ,, ,,	,,	,,	23	,,
,, ,,	The Rhætic Beds	,, ,, ,,	*Trans.*	I.	1	1889
,, ,,	A Chapter in the Physical Geography of the Past	,, ,, ,,	,,	,,	37	,,
Cheetham, W.	From the Millstone Grits to the Silurians	Leeds Geol. Assoc.	,,	IV.	194	,,
Christy, M., and W. H. Dalton	Notes on an Alluvial Deposit in the Cann Valley, with a List of the Mollusca occurring therein	Essex F. C.	*Essex Naturalist*	III.	1	,,
Claypole, Prof. E. W.	The Eccentricity Theory of Glacial Cold *versus* the Facts	Edinb. Geol. Soc.	*Trans.*	V.	534	1888
Craig, G.	The Culbin Sandhills	,, ,,	,,	,,	524	,,
Crosskey, Dr. H. W.	Notes on the Glacial Geology of the Midlands	Birm. Phil. Soc.	*Proc.*	VI.	169	—
Davis, J. W.	Summary of Geological Literature relating to Yorkshire, published during 1888	Yorks. Geol. Poly. Soc.	,,	XI.	128	1889
Dawkins, Prof. W. Boyd	On the Conglomerates of the South of the Island	I. of Man N. H. A. Soc.	*Yn Lioar Manninagh*	I.	16*a*	,,
,, ,,	On the Clay Slates and Phyllites of the South of the Isle of Man, and a Section of the Foxdale Mine, Isle of Man	Manch. Geol. Soc.	*Trans.*	XX.	53	1888
De Rance, C. E.	Notes on the Vale of Clwyd Caves	Yorks. Geol. Poly. Soc.	*Proc.*	XI.	1	1889
Dickson, E.	Geological Notes on the Preston Dock Works and Ribble Development Scheme	Liv'pool Geol. Soc.	,,	V.	369	1888
Editor	Excursion of Edinburgh and Glasgow Geological Societies to Mid-Calder, June 30, 1888	Edinb. Geol. Soc.	*Trans.*	,,	549	,,
Elwes, J. W.	Sections on the Railway from Foreham to Netley	Hants. F. C.	*Proc.*	2	31	—

Section C.—GEOLOGY (*continued*).

Name of Author	Title of Paper	Abbreviated Title of Society	Title of Publication	Volume or Part	Page	Published
Firth, W. A.	The Diatomaceous Deposits at Lough Mourne	Belfast Nat. F. C.	*Report and Proc.*	III.	62	1888
Fordham, H. G.	A Record of Water-level in a deep Chalk Well at Barley, Herts.	Herts. N. H. Soc.	*Trans.*	V.	20	"
Forrester, J.	Hæmatite Iron Ore found in the neighbourhood of Kirkcaldy	E. Scot. Union	*Proc.*	For 1888	10	1889
Forster, T. E.	Coal Nodules from the Bore-hole Seam at Newcastle, New South Wales	N. Eng. Inst.	*Trans.*	37	145	—
Fraser, J.	Clay Shell bed at Clava	Inverness Sci. Soc.	"	II.	169	—
Gardner, J. S.	The Trap Formation of Ulster	Belfast Nat. F. C.	*Report and Proc.*	I.	49	—
Goodchild, J. G.	The Physical History of Greystoke Park and the Valley of the Petteril	Cumb. West. Assoc.	*Trans.*	XIII.	89	1888
" "	The Old Lakes of Edenside	" "	"	"	105	"
Green, Prof. A. H.	Glassy Lavas and Devitrification	Leeds Geol. Assoc.	"	IV.	186	1889
Harker, A.	The Igneous Dykes of the North of England	Yorks. Nat. Union	*The Naturalist*	For 1888	349	1888
Harman, F. E.	The Cerros of Famatina	Cornwall R. Geol. Soc.	*Report and Trans.*	XI.	162	1889
Hewitt, W.	Notes on Glacial Deposits and Markings in the South of the Isle of Man	Liv'pool Geol. Soc.	*Proc.*	V.	352	1888
Holgate, B.	The Magnesian Limestones of Yorkshire	Leeds Geol. Assoc.	*Trans.*	IV.	182	1889
" "	Notes on the Lake District	" "	"	"	204	"
Holland, P., and E. Dickson	Examination of Quartzite from Nills Hill, Pontesbury	Liv'pool Geol. Soc.	*Proc.*	V.	380	1888
Holmes, T. V.	The Subterranean Geology of South-eastern England	Essex F. C.	*Essex Naturalist*	II.	138	"
Horne, J.	Andelusite Schists in Banffshire and Aberdeenshire.	Inverness Sci. Soc.	*Trans.*	II.	224	—
Johnstone, A.	The Microscopic Determination of Igneous Rocks	Edinb. Geol. Soc.	"	V.	488	1888
Jolly, W.	Succession of Rocks in the North-west of Sunderland	Inverness Sci. Soc.	"	II.	199	—
Kendall, P. F.	The Volcanic Phenomena of Mull	Manch. Geol. Soc.	"	XX.	114	1889
" "	On a large Boulder found in Oxford Street Manchester	" "	"	"	140	"
Kidson, E.	Evidences of Glacial Action in Snowdonia	Nott. Nat. Soc.	"	For 1888	14	"
Lamplugh, G. W.	The Yellowstone Geysers	Leeds Geol. Assoc.	"	IV.	179	"

Law, R.	On Bones of Pleistocene Animals found in a broken-up Cave in a Quarry near Matlock, Derbyshire	Rochdale Lit. Sci. Soc.	”	I	15	1888
Lean, J.	Dolomitic Conglomerate of Bristol	Bristol Nat. Soc.	*Proc.*	V.	207	”
McDonald, K.	Glacial Drift in Craggy Burn	Inverness Sci. Soc.	*Trans.*	II.	47	—
McNair, P.	The Geology of the Breadalbane District of Perthshire	Perth Soc. N. Sci.	*Trans. and Proc.*	I.	52	1888
Mansell-Pleydell, J. C.	Fossil Reptiles of Dorset	Dorset N. H. A. F. C.	*Proc.*	IX.	1	—
Martin, F. W.	First Report upon the Distribution of Boulders in South Shropshire and South Staffordshire	Birm. Phil. Soc.	”	VI.	93	—
Melvin, J.	Inaugural Address	Edinb. Geol. Soc.	*Trans.*	V.	485	1888
” ”	The Parallel Roads or ‘Seter’ of Norway	” ”	”	”	516	”
Morgan, Prof. C. Lloyd	The Mendips: A Geological Reverie	Bristol Nat. Soc.	*Proc.*	”	236	”
” ”	The Stones of Stanton Drew: Their Source and Origin	” ”	”	”	261	”
Morison, W.	A New Mineral Tar in Old Red Sandstone, Ross-shire	Edinb. Geol. Soc.	*Trans.*	”	500	”
Morton, G. H.	Local Historical, Post-Glacial, and Pre-Glacial Geology	Liv’pool Geol. Soc.	*Proc.*	”	303	”
” ”	Stanlow, Ince, and Frodsham Marshes	” ”	”	”	349	”
Oldham, T.	On the Cause of Earthquakes, of the Dislocation and Overlapping of Strata, and of Similar Phenomena	Manch. Geol. Soc.	*Trans.*	XX.	128	1889
Quilter, H. C.	The Rhætics of Leicestershire	Leicester Lit. Phil. Soc.	”	XI.	14	”
Reade, T. M.	Notes on the Geology of St. David’s, Pembrokeshire	Liv’pool Geol. Soc.	*Proc.*	V.	358	1888
” ”	Notes on a large Boulder found in driving a Sewer Heading in Oxford Road, Manchester	” ”	”	”	377	”
” ”	The New Red Sandstone and the Physiography of the Triassic Period	Yorks. Nat. Union	*The Naturalist*	For 1889	108	1889
Richardson, R.	Obituary Notice of Mr. Henry Cadell, of Grange	Edinb. Geol. Soc.	*Trans.*	V.	502	1888
” ”	Obituary Notice of Dr. Hayden	” ”	”	”	532	”
” ”	On the Earthquake Shocks experienced in the Edinburgh District on Friday, January 18, 1889	R. Scot. Geog. Soc.	*Magazine*	V.	135	1889
Robson, Rev. G.	Past and Present Glaciers in Norway	Inverness Sci. Soc.	*Trans.*	II.	179	—

Section C.—GEOLOGY (*continued*).

Name of Author	Title of Paper	Abbreviated Title of Society	Title of Publication	Volume or Part	Page	Published
Roeder, C.	Some further Remarks on the Oxford Street Section	Manch. Geol. Soc.	*Trans.*	XX.	163	1889
Sington, T.	On the recently-disclosed Sections of the Superficial Strata along Oxford Street, Manchester	" "	"	XIX.	603	1888
Spencer, J.	On the Occurrence of a Boulder of Granitoid Gneiss, or Gneissoid Granite, in the Halifax Hard Bed Coal	Yorks. Geol. Poly. Soc.	*Proc.*	XI.	96	1889
Symons, B.	The Gold Fields of Nova Scotia	Cornw. Min. Assoc. Inst.	*Trans.*	II.	—	—
Tate, A. N.	On the Colouring Matter of the Mineral 'Blue John'	Liv'pool Geol. Soc.	*Proc.*	V.	384	1888
Thompson, B.	The Upper Lias of Northamptonshire	N'ton. N. H. Soc.	*Journal*	5	54	"
Topley, W.	Recent Earthquakes	Croydon M. N. H. C.	*Proc. and Trans.*	3	lxx.	1889
Turner, W.	The Porcelain Works at Nanthgarw	Cardiff Nat. Soc.	*Report and Trans.*	XX.	1	1888
Vine, G. R.	Notes on the Polyzoa of Caen and Ranville now preserved in the Northampton Museum	N'ton. N. H. Soc.	*Journal*	5	1	"
" "	Notes on the Classification of the Palæozoic Polyzoa	Yorks. Geol. Poly. Soc.	*Proc.*	XI.	20	1889
" "	A Monograph of Yorkshire Carboniferous and Permian Polyzoa. Part I.	" "	"	"	68	"
Wallace, T.	Shell Bed at Adersier	Inverness Sci. Soc.	*Trans.*	II.	176	—
" "	Recent Geological Changes in the Moray Frith	" "	"	"	380	—
Waller, T. H.	The Separation of Rock Constituents by means of Heavy Solutions	Birm. N. H. M. Soc.	*Mid. Naturalist*	12	91	1889
Watts, W.	Distribution of Erratics and Boulder Clay on the lower portions of the Drainage Area of the Oldham Corporation Waterworks	Manch. Geol. Soc.	*Trans.*	XIX.	584	1888
" "	On the Use of Roburite and other Explosives in Mines	" "	"	XX.	211	1889
Worth, R. N.	Some Detrital Deposits associated with the Plymouth Limestone	Cornw. R. Geol. Soc.	*Report and Trans.*	XI.	151	"

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Abel, W. J.	Touch, including the Genesis of Sensation	Nott. Nat. Soc.	*Trans.*	For 1888	36	1889
Adams, L. E.	List of Manks Land and Freshwater Shells	I. of Man. N. H. A. Soc.	*Yn Lioar Manninagh*	I.	9*a*	"
Angus, W. C.	Notes on the Turnstone, *Strepsilas interpres*, Lin.	Glasgow N. H. Soc.	*Trans.*	II.	180	"
Ashby, E.	Notes on the Fauna of South Australia.	Holmesdale N. H. C.	*Proc.*	For 1886–7	90	1888
Atkinson, Rev. J. C.	Alarm Note of the Woodcock (*Scolopax rusticola*).	Yorks. Nat. Union	*The Naturalist*	For 1888	236	"
" "	Wild Cherry Stones used as food by the Long-tailed Field-mouse	" "	" "	For 1889	54	1889
Babington, C. C.	List of Plants noticed at Fylingdales (Robin Hood's Bay) in September 1882	" "	" "	For 1888	265	1888
Baker, J. G.	On Kew Gardens and some of the Botanical Statistics of the British Possessions	Birm. N. H. M. Soc.	*Mid. Naturalist*	11	165	"
" "	North Yorkshire: Studies of its Botany, Geology, Climate, and Physical Geography (second instalment). Second Edition	Yorks. Nat. Union	*Trans.*	3	49	1889
Banks, E.	Occurrence in Dorset of *Butalis siculla*, a new British Moth	Dorset N. H. A. F. C.	*Proc.*	IX.	118	—
Barclay, W.	An August Ramble on the Forfarshire Coast of the Tay	Perths. Soc. N. Sci.	*Trans. and Proc.*	I.	45	1888
Beeby, W. H.	On the Occurrence of *Equisetum litorale* (Kuhl.) in Britain	Holmesdale N. H. C.	*Proc.*	For 1886–7	10	"
Bell, Rev. T.	Flora and Fauna of Keig	Inverness Sci. Soc.	*Trans.*	II.	332	—
Bennett, A.	*Geranium macrorhizum* and *Carex gibsoni* in West Yorkshire	Yorks. Nat. Union	*The Naturalist*	For 1889	80	1889
Binnie, F. G.	List of *Cecidomyidæ* found near Tadcaster	" "	" "	"	101	"
Blathwayt, Lieut.-Col.	List of Terrestrial *Hemiptera Heteroptera*, taken in the neighbourhood of Bath	Bath N. H. A. F. C.	*Proc.*	VI.	432	"
Block, Quart.-Mast. Serj. C.	Butterflies and Moths	Rochester N. C.	*Roch. Naturalist*	1	382,393	1888
Bowyer, R. W.	Some Methods of Moth Collecting	Herts N. H. Soc.	*Trans.*	V.	23	"
Bridge, Prof. T. W.	Some Points in the Cranial Anatomy of Polypterus	Birm. Phil. Soc.	*Proc.*	VI.	118	—
" "	The Air Bladder in certain Siluroid Fishes	" "	"	"	131	—
British Association Committee	The Museums of the North of England	Yorks. Nat. Union	*The Naturalist*	For 1889	45	1889

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Name of Author	Title of Paper	Abbreviated Title of Society	Title of Publication	Volume or Part	Page	Pub-lished
Broom, R.	On a Monstrosity of the Common Earthworm, *Lumbricus terrestris*, L.	Glasgow N. H. Soc.	*Trans.*	II.	203	1889
Brown, H. T.	A Grain of Barley	Burt. N. H. A. Soc.	,,	I.	86	,,
Burgess, E. W.	Foraminifera of Oban, Scotland	Birm. N. H. M. Soc.	*Mid. Naturalist*	12	77	,,
Cambridge, Rev. O. P.	On *Walckenaëra interjecta*, a new Spider from Hoddesdon	Herts N. H. Soc.	*Trans.*	V.	18	1888
Cameron, P.	On Parthenogenesis in the Hymenoptera	Glasgow N. H. Soc.	,,	II.	194	1889
,, ,,	On the Occurrence on Ben Lawers of *Arenetra pilosella*, Gr., a Genus of Ichneumonidæ new to the British Fauna	,, ,,	,,	,,	202	,,
Campbell, F. M.	Anniversary Address (1888): The Means of Protection possessed by Plants	Herts N. H. Soc.	,,	V.	1	1888
,, ,,	Anniversary Address (1889): Structural Variations in the Eyes of Animals in reference to their Function	,, ,,	,,	,,	107	1889
Carr, J. W.	Notes on the lowest Vertebrate-Anatomy and Development of the Lancelet (*Amphioxus lanceolatus*)	Nott. Nat. Soc.	,,	For 1888	24	,,
Carter, J. W.	Some Ingleborough Coleoptera	Yorks. Nat. Union	*The Naturalist*	For 1888	245	1888
Carter T.	Phanerogamous Parasites of Leicestershire	Leicester Lit. Phil. Soc.	*Trans.*	X.	16	1889
Carter, W. A.	Marine and Freshwater Fishes	Croydon M. N. H. C.	*Proc. and Trans.*	3	lxviii.	,,
Chamberlain, W.	Notes on Non-Volant Birds	E. Scot. Union	*Separate Pub.*	—	—	1888
Chase, R. W.	Notes upon the recent Occurrence of Pallas' Sand Grouse	Birm. N. H. M. Soc.	*Mid. Naturalist*	11	186	,,
Christy, M.	On the reported Breeding of the Scops Owl in Essex	Essex F. C.	*Essex Naturalist*	III.	—	1889
Clarke, W. Eagle	The Irruption of Pallas' Sand Grouse	Yorks. Nat. Union	*The Naturalist*	For 1888	170	1888
,, ,,	A Yorkshire Bird new to the European Avifauna?	,, ,,	,, ,,	For 1889	79	1889
,, ,,	On the Occurrence of *Emberiza cioides* Brandt in Yorkshire	,, ,,	,, ,,	,,	113	,,
Cockerell, T. D. A.	North of England Specimens in the Collection at the British Museum	,, ,,	,, ,,	For 1888	227	1888
Cole, W.	The Reappearance of Pallas' Sand Grouse (*Syrrhaptes paradoxus*) in Britain and in Essex	Essex F. C.	*Essex Naturalist*	II.	61	,,

Cooke, M. C.	Contributions towards a List of the Fungi of Essex—*Discomycetes*	” ”	” ”	”	189	”
Cordeaux, J.	Notes on the Occurrence of Pallas' Sand Grouse in the Spurn District in the Spring of 1888.	Yorks. Nat. Union	*The Naturalist*	For 1888	195	”
” ”	Occurrences of Pallas' Sand Grouse at Heligoland	” ”	” ”	”	197	”
” ”	Notes from the Spurn in the Spring of 1888	” ”	” ”	”	202	”
” ”	Crossbills in Heligoland	” ”	” ”	”	224	”
” ”	Occurrence of the American Pectoral Sandpiper on the Yorkshire Coast	” ”	” ”	”	351	”
” ”	Notes from the Yorkshire and Lincolnshire Coasts in the Autumn of 1888	” ”	” ”	For 1889	1	1889
” ”	Bottle-nosed Dolphin in the Humber	” ”	” ”	”	6	”
” ”	Bird Notes from the Humber District	” ”	” ”	”	44	”
” ”	Ornithological Notes from N.E. Lincolnshire and Holderness	” ”	” ”	”	129	”
Craig-Christie, A.	Notes on 'The Flora of West Yorkshire'	” ”	” ”	For 1888	225	1888
Crick, W. D.	*Helix pomatia* in Northamptonshire	N'ton. N. H. Soc.	*Journal*	5	156	”
Crosfield, A. J.	A Naturalist's Ramble round Reigate	Holmesdale, N. H. C.	*Proc.*	For 1886–7	30	”
” ”	Birds observed in December 1886 and January 1887 in Bombay and the Central Provinces of India	” ”	”	”	70	”
” ”	Notes on Wild Fowl seen in Central India	” ”	”	”	81	”
Crouch, W.	Record of a Specimen of Rudolphi's Rorqual	Rochester N. C.	*Roch. Naturalist*	1	361	”
Dale, W.	List of Private Collections in Hampshire of Objects of Natural History and Antiquity	Hants F. C.	*Proc.*	2	24	—
Davies, J. H.	Notes on a Waterhen's Nest	Belfast N. H. Phil. Soc.	*Report and Proc.*	For 1888	41	1888
De-Toni, G. B.	Notes on Botanical Nomenclature	Yorks. Nat. Union	*The Naturalist*	”	157	”
Dickson, Jas.	The Birds of Fortwilliam Park	Belfast N. H. Phil. Soc.	*Report and Proc.*	”	36	”
Druce, G. C.	The Flora of Northamptonshire	N'ton N. H. Soc.	*Journal*	5	29, 117 149	”
Durrant, J. H.	Contributions to the Knowledge of the Entomological Fauna of Hertfordshire. No. 1.—Lepidoptera	Herts N. H. Soc.	*Trans.*	V.	63	”
Editor	Bibliography of Coleoptera for North of England, 1884 to 1887	Yorks. Nat. Union	*The Naturalist*	For 1888	203	”
”	Bibliography of Mollusca for North of England, 1886 and 1887	” ”	” ”	”	247	”
”	Bibliography of Neuroptera and Trichoptera of North of England, 1884 to 1887	” ”	” ”	”	285	”

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Editor	Bibliography of Diptera for North of England, 1884 to 1887	Yorks. Nat. Union	*The Naturalist*	For 1889	17	1889
"	Bibliography of Mammalia for North of England, 1886 and 1887	" "	" "	"	115	"
"	Bibliography of Birds for North of England, 1886	" "	" "	"	145	"
Ellis, J. W.	Lepidopterous Fauna of Lancashire and Cheshire: Tortricina	" "	" "	"	25	"
Entomological Section	The Lepidoptera of Burton-on-Trent and Neighbourhood	Burt. N. H. A. Soc.	*Trans.*	I.	114	"
Eyre, Rev. W. L. W.	List of Hants Fungi	Hants F. C.	*Proc.*	2	22	—
Fielding, Rev. C. H.	General Wild Flowers	Rochester N. C.	*Roch. Naturalist*	1	352, 366 401	1888 1889
Fitch, E. A.	Essex Heronries	Essex F. C.	*Essex Naturalist*	II.	171	1888
Fitch, E. A., and M. Christy	A Visit to an Essex Gullery, with Notes on the Birds frequenting the Marshes round Tollesbury	" "	" "	"	193	"
Fitzgerald, H. P.	The Mollusca of North Hants	Hants F. C.	*Proc.*	2	26	—
Fraser, Rev. Mr.	Flowering Plants	Inverness Sci. Soc.	*Trans.*	II.	92	—
French, J., and W. H. Dalton	On the Mollusca of the Shell Marl occurring at Felstead and in other parts of Essex	Essex F. C.	*Essex Naturalist*	III.	—	1889
Gain, W. A.	A few Notes on the Food and Habits of Slugs and Snails	Yorks Nat. Union	*The Naturalist*	For 1889	55	"
Gilbert, H. W.	How and why Animals differ	Holmesdale N. H. C.	*Proc.*	For 1886–7	12	1888
Glasson, W. A.	On the Occurrence of Foreign Plants in West Cornwall	Penz. N. H. A. Soc.	*Rep. and Trans.*	III.	—	1889
Gorrip, J. A.	Insectivorous Plants	Inverness Sci. Soc.	*Trans.*	II.	244	—
Greening, L.	Newts near Warrington	Yorks. Nat. Union	*The Naturalist*	For 1888	243	1888
" "	The Natterjack Toad in Cheshire and Lancashire	" "	" "	"	357	"
Grove, W. B.	President's Address on the Progress of Bacteriology	Birm. N. H. M. Soc.	*Mid. Naturalist*	12	73	1889
Gurney, J. H., jun.	Utility of the Barn Owl	Yorks. Nat. Union	*The Naturalist*	For 1888	264	1888
Harrison, A. J.	Remarks about Seals	Bristol Nat. Soc.	*Proc.*	V.	290	"

Harting, J. E.	On the Introduction of a new Game Bird (the *Tinamu*) into Essex, with some account of its habits	Essex F. C.	*Essex Naturalist*	II.	102	"
" "	Wild Fowl Decoys in Essex	" "	" "	"	159	
Hay, Col. H. M. D.	Additional Notes on the Report of the Ornithology of the East of Scotland from Fife to Aberdeenshire, inclusive (1885)	E. Scot. Union	*Proc.*	For 1888	27	1889
" "	Note on the Occurrence of the Desert Wheat-ear in the Tay District	Perth. Soc. N. Sci.	*Trans. and Proc.*	I.	90	1888
Hervey, Rev. A. C.	Lepidoptera of Hampshire	Hants F. C.	*Proc.*	2	19	—
Hobkirk, C. P.	*Plagiothecium undulatum* in Lincolnshire in Prehistoric Times	Yorks. Nat. Union	*The Naturalist*	For 1889	4	1889
Hodges, Rev. E. R.	Symbiosis, or Odd Fellowship in Nature	Nott. Nat. Soc.	*Trans.*	For 1888	29	"
Holmes, W. M.	The Epidermic Growths of Vertebrate Animals	Croydon M. N. H. C.	*Proc. and Trans.*	3	lxxii.	"
Holt, G. A.	*Plagiothecium borrerianum*	I. of Man N. H. A. Soc.	*Yn Lioar Manninagh*	I.	10	"
" "	*Mnium Stellare*	" " "	" "	"	19	"
Hopkinson, J.	A Naturalist's Calendar for the South-West of Hertfordshire	Herts N. H. Soc.	*Trans.*	V.	129	"
" "	Notes on Birds observed in Hertfordshire during the year 1888	" "	"	"	139	"
Horsnail, E.	The Marine Aquarium, its History and Management	Holmesdale N. H. C.	*Proc.*	For 1886-87	1	1888
Humphreys, J.	The Suppression and Specialisation of Teeth	Birm. Phil. Soc.	"	VI.	137	—
Hunt, Dr. T.	The Roses of Ashworth	Rochdale Lit. Sci. Soc.	*Trans*	I.	113	1888
Jackson, J. A.	Notes on the Lapwing near Garstang	Yorks. Nat. Union	*The Naturalist*	For 1888	269	"
Jones, Col. A. M.	Varieties of Ferns in the Bristol District	Bristol Nat. Soc.	*Proc.*	V.	216	"
" "	The Crossing of Ferns	" "	"	"	339	"
Kermode, P. M. C.	Our Insect Enemies: Wire Worms	I. of Man N. H. A. Soc.	*Yn Lioar Manninagh*	I.	19, 21	1889
" "	Our Insect Enemies: Cutworm	" " "	" "	"	29	"
Kew, H. W.	Diptera from Alford and Louth, Lincolnshire	Yorks. Nat. Union	*The Naturalist*	For 1888	217	1888
" "	Notes made in 1888 upon *Arion ater* and some other Slugs	" "	" "	For 1889	103	1889
Knubley, Rev. E. P.	The British Association at Bath	" "	" "	For 1888	308	1888
Lee, P. F.	*Sparganium ramosum*, var. *microcarpum*, in Yorkshire	" "	" "	"	200	"
" "	Bibliography of Cryptogamic Botany for North of England, 1886 and 1887	" "	" "	"	361	"

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Lees, F. A.	A new West Yorkshire Plant (*Pyrola rotundifolia*)	Yorks. Nat. Union	*The Naturalist*	For 1888	267	1888
" "	Notes on the West Yorkshire Flora	" "	" "	"	303	"
Letts, Prof. E. A.	Pasteur's Life and Researches	Belfast N. H. Phil. Soc.	*Report and Proc.*	"	23	"
Lightfoot, W.	Fertilisation of Flowers	Rochester N. C.	*Roch. Naturalist*	1	377	1889
Lilford, Lord	Notes on the Birds of Northamptonshire	N'ton. N. H. Soc.	*Journal*	5	41, 85, 160	1888
" "	Notes on the Ornithology of Northamptonshire	" "	"	"	133	"
Lindsay, Dr. J. A.	The alleged Decay of National Physique	Belfast N. H. Phil. Soc.	*Report and Proc.*	For 1888	43	"
Littleboy, J. E.	Notes on Birds observed in Hertfordshire in 1887, and on the Birds frequenting the Tring Reservoirs	Herts N. H. Soc.	*Trans.*	V.	76	"
M'Andrew, J.	Botanical Notes from Wigtownshire and Kirkcudbrightshire	Glasgow N. H. Soc.	"	II.	207	1889
McDonald, K.	Deep Sea Exploration	Inverness Sci. Soc.	"	"	162	—
Macfarlane, J.	Sub-Alpine Plants of Ben Hawers	" "	"	"	315	—
McGregor, T. M.	Notes on the Aculeate Hymenoptera, with a List of the Wild Bees and Wasps in Perthshire in 1887	Perths. Soc. N. Sci.	*Trans. and Proc.*	I.	65	1888
Macleod, W.	Insectivorous Plants	Inverness Sci. Soc.	*Trans.*	II.	161	—
Macpherson, Rev. H. A.	Report on Pallas' Sand Grouse (*Syrrhaptes paradoxus*) in the North-West of England	Cumb. West. Assoc.	"	XIII.	59	1888
" "	Additional Notes on Pallas' Sand Grouse	" "	"	"	114	"
" "	Gyrfalcon in the Lake District	Yorks. Nat. Union	*The Naturalist*	For 1888	223	"
Macpherson, Rev. H. A., and W. Duckworth	Ornithological Record for Cumberland, January 1887 to June 1888	Cumb. West. Assoc.	*Trans.*	XIII.	25	"
Marquand, E. D.	Our Common Garden Snails	Penz. N. H. A. Soc.	*Report and Trans.*	III.	—	1889
Marshall, W. P., and C. Pumphrey	Notes on a Tour in Norway, and Collection of Plants	Birm. N. H. M. Soc.	*Mid. Naturalist*	12	1	"
Mason, J. E.	A List of some *Hemiptera Heteroptera* of Lincolnshire, with notes on collecting	Yorks. Nat. Union	*The Naturalist*	For 1888	287	1888
" "	Additions to the List of some *Hemiptera Heteroptera* of Lincolnshire	" "	" "	For 1889	128	1889

Matthews, C. G.	Notes on Micro-organisms	Burt. N. H. A. Soc.	*Trans.*	[illegible]	[illegible]	[illegible]
Meldola, Prof. R.	Emission of Scent by a Deltoid Moth	Essex F. C.	*Essex Naturalist*	II.	113	1888
Meyrick, E.	Notes on Insects	Marlb. Coll. N. H. Soc.	*Report*	37	98	1889
Mitchell, F. S.	Is the Starling Double-brooded?	Yorks. Nat. Union	*The Naturalist*	For 1889	112	"
Morgan, Prof. C. Lloyd	Elimination and Selection	Bristol Nat. Soc.	*Proc.*	V.	273	1888
Moule, H. J.	Rooks	Dorset N. H. A. F. C.	"	IX.	123	—
Murray, Rev. R. P.	Notes on Spring Flowers	I. of Man N. H. A. Soc.	*Yn Lioar Manninagh*	I.	11	1889
Nelson, T. H.	Ornithological Notes from Redcar and Tees Mouth in 1887 and 1888	Yorks. Nat. Union	*The Naturalist*	For 1889	81	"
Parker, Prof. W. N.	On the African Mud-fish (*Protopterus annectens*)	Cardiff Nat. Soc.	*Report and Trans.*	XX.	69	"
Pearcey, F. G.	Notes on the Foraminifera of the Faroe Channel and Wyville Thomson Ridge, with a description of a new Species of *Hyperammina*	Glasgow N. H. Soc.	*Trans.*	II.	163	"
Percival, J.	The Flora of Wensleydale, North-West Yorkshire: Additions	Yorks. Nat. Union	*The Naturalist*	For 1888	159	1888
Phillips, W. H.	Variations observed in the Growth of Mistletoe	Belfast Nat. F.C.	*Report and Proc.*	III.	58	—
Porritt, G. T.	*Deilephila galii* in 1888	Yorks. Nat. Union	*The Naturalist*	For 1888	298	1888
Powell, J. T.	Epping Forest Rubi	Essex F. C.	*Essex Naturalist*	III.	—	1889
Praeger, R. L.	List of the Marine Shells of the North of Ireland	Belfast Nat. F.C.	*Report and Proc.*	II.	App.III.	—
Proger, T. W.	The Common Badger, *Meles taxus*	Cardiff Nat. Soc.	*Report and Trans.*	XX.	42	1888
Ralfs, J.	*Drosera rotundifolia*	Penz. N. H. A. Soc.	" "	III.	—	1889
Roberts, G.	*Helix hortensis* and its Variations	Yorks. Nat. Union	*The Naturalist*	For 1888	232	1888
Robertson, D.	On the Local Distribution of *Pennatula phosphorea*, Lin., *Virgularia mirabilis*, Lam., and *Paronaria quadrangularis*, Pall.	Glasgow N. H. Soc.	*Trans.*	II.	211	1889
" "	The Pike, *Esox lucius*, Lin.	" "	"	"	212	"
" "	*Isocardia cor*, Lin.	" "	"	"	215	"
" "	*Hyas araneus*, Lin.	" "	"	"	216	"
" "	*Stenorhynchus longirostris*, Fabr.	" "	"	"	218	"
" "	On some Differences between the Marine Faunas of the Firth of Clyde and Firth of Forth	" "	"	"	220	"
Robinson, T. N.	The Birds of our Marshes	Cumb. West. Assoc.	"	XIII.	47	1888
Roebuck, W. D.	Up Buckden Pike with the Aneroid	Yorks. Nat. Union	*The Naturalist*	For 1889	144	1889
Roebuck, W. D., & Rev. E. P. Knubley	Annual Report for 1888	" "	" "	"	7	"

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Rooper, G.	Birds: their Nests and Habits	Herts N. H. Soc.	*Trans.*	V.	97	1889
Selys-Longchamps, E. de	Insect Migration at Heligoland	Yorks. Nat. Union	*The Naturalist*	For 1888	219	1888
Sherborn, C. D.	Notes on the Foraminifera, with especial reference to variation in the Test, together with collected information as to their sex and reproduction	Croydon M. N. H. C.	*Proc. and Trans.*	3	133	1889
Shore, T. W.	Ancient Hants Forests	Hants F. C.	*Proc.*	2	40	—
Shore, Dr. T. W.	Examination of a Gelatinous growth from a Pond	"	"	"	65	—
Silvester, F. W.	Report on Insects observed in Hertfordshire in 1887	Herts N. H. Soc.	*Trans.*	V.	89	1888
" "	Report on Insects observed in Hertfordshire in 1888	" "	"	"	134	1889
Smart, Rev. R. W. J.	Bird-nesting on Scilly	Penz. N. H. A. Soc.	*Rep. and Trans.*	III.	—	"
Smith, G. M.	On Wine Drinking, and its Effects on the Human Body	Bristol Nat. Soc.	*Proc.*	V.	329	1888
Smith, J.	Notes on some of the rarer Plants occurring in the Valley of the Garnock, Ayrshire	Glasgow N. H. Soc.	*Trans.*	II.	245	1889
Smith, Dr. R. S.	The Structure, Decay, and Preservation of the Teeth	Bristol Nat. Soc.	*Proc.*	V.	286	1888
Smith, Rev. T. N. H.	Notes on Plants	Marlb. Coll. N. H. Soc.	*Report*	37	78	1889
Smithson, T. S.	Leaf Nectaries	Rochdale Lit. Sci. Soc.	*Trans.*	I.	85	1888
Somerville, A.	Notes on the Flora of the Island of Barra	Glasgow N. H. Soc.	"	II.	183	1889
" "	Dredging off Portincross, Ayrshire	" "	"	"	189	"
Soppitt, H. T., and G. Massee	Fungus Foray at Bramham and Harewood Parks	Yorks. Nat. Union	*The Naturalist*	For 1888	321	1888
Stabler, G.	On the Hepaticæ and Musci of Westmoreland	" "	" "	"	313	"
Sterry, A. C.	The Life and Habits of Crabs	Holmesdale N. H. C.	*Proc.*	For 1886-87	65	"
Storer, G. H.	Some Notes upon the Habits and Voices of our British Song Birds, with special reference to those found in Leicestershire	Leicester Lit. Phil. Soc.	*Trans.*	X.	21	1889
Stuart, M. G.	A Naturalist's Calendar for Dorset	Dorset N. H. A. F. C.	*Proc.*	IX.	130	—
Sutherland, Dr.	Nudibranchiate Mollusca	Inverness Sci. Soc.	*Trans.*	II.	337	—

Swainson, G.	Results of Dredging Excursion to Dalby by the Wesley Scientific Society in August, 1888	Isle of Man N. H. A. Soc.	*Yn Lioar Manninagh*	I.	14A	1889
Talbot, Rev. T.	*Brassica monensis*	,, ,,	,, ,,	,,	13	,,
Thomas, T. H.	The Colouration of the Cubs of the Lion and the Puma	Cardiff Nat. Soc.	*Report and Trans.*	XX.	40	1888
,, ,,	The Identity of some Plants native to the Rocky Mountains with local Species	,, ,,	,, ,,	,,	46	,,
,, ,,	Note upon an Ants' Nest in a Cardiff Garden	,, ,,	,, ,,	,,	106	1889
Thornewill, Rev. C. F., T. Gibbs, J. E. Nowes, and J. G. Wells	Calendar of Nature for 1887	Burt. N. H. A. Soc.	*Report*	Twelfth	29	1888
Trail, Prof. J. W. H.	Report for 1888 on the Fungi of the East of Scotland	E. Scot. Union	*Proc.*	For 1888	37	1889
,, ,,	The Gall-making Diptera of Scotland	,, ,,	,,	,,	41	,,
,, ,,	The Gall-making Hymenoptera of Scotland (exclusive of those that live on Oaks)	Perths. Soc. Nat. Sci.	*Trans. and Proc.*	I.	72	1888
Turner, R.	The Cadzow Herd of White Cattle	Glasgow N. H. Soc.	*Trans.*	II.	222	1889
Vachell, Dr. C. T.	Note on a Specimen of a Fossil Ganoid Fish	Cardiff Nat. Soc.	*Report and Trans.*	XX.	110	,,
Various	The Yorkshire Naturalists' Union in Lower Wensleydale	Yorks. Nat. Union	*The Naturalist*	For 1888	171	1888
,,	The Irruption of Pallas' Sand Grouse	,, ,,	,, ,,	,,	198, 221	,,
,,	Yorkshire and Lancashire Naturalists at Saddleworth	,, ,,	,, ,,	,,	211	,,
,,	The Yorkshire Naturalists' Union at Robin Hood's Bay	,, ,,	,, ,,	,,	237	,,
,,	The Yorkshire Naturalists' Union at Market Weighton	,, ,,	,, ,,	,,	277	,,
Wallis, H. M.	On the Birds of Arran More	Holmesdale N. H. C.	*Proc.*	For 1886-87	98	,,
Watson, J.	The Ornithology of Skiddaw, Sca Fell, and Helvellyn	Yorks. Nat. Union	*The Naturalist*	For 1888	161	,,
,, ,,	Notes on the Birds of the Lake District	,, ,,	,, ,,	,,	201	,,
Watts, W.	The Swallow	Rochdale Lit. Sci. Soc.	*Trans.*	I.	19	,,
Wells, J. G.	The Wild Plants of Foreign Barley Fields	Burt. N. H. A. Soc.	,,	I.	75	1889
West, W.	Additional Localities for the Vascular Plants of the West Riding Flora	Yorks. Nat. Union	*The Naturalist*	For 1888	299	1888
,, ,,	Additions to the Algæ of West Yorkshire	,, ,,	,, ,,	For 1889	87	1889
White, Dr. F. B.	Opening Address	Perth Soc. N. Sci.	*Trans. and Proc.*	I.	xix.	1888
,, ,, ,,	Presidential Address	,, ,,	,, ,,	,,	xxvii.	,,

Section D.—BIOLOGY (*continued*).

Name of Author	Title of Paper	Abbreviated Title of Society	Title of Publication	Volume or Part	Page	Published
White, J. W.	Flora of the Bristol Coalfield	Bristol Nat. Soc.	*Proc.*	V.	229	1888
Whitlock, F. B.	Notes on the Reed Warbler	Yorks. Nat. Union	*The Naturalist*	For 1888	355	"
" "	Autumn and Winter Notes from Notts	" "	" "	For 1889	113	1889
Whitwell, W.	Notes on Settle Plants	" "	" "	For 1888	307	1888
Wickert, C. O.	The First International Ornithological Congress, 1884	I. of Man N. H. A. Soc.	*Yn Lioar Manninagh*	I.	38	1889
Wilson, W., jun.	Notes on the Botany of the District around Alford	E. Scot. Union	*Proc.*	For 1888	33	"
Windle, Dr. B. C. A.	A Note on the Extensor Tendons of the Manus of Apes	Birm. Phil. Soc.	"	VI.	22	—
" "	Congenital Malformations and Heredity	" "	"	"	26	—
Woodward, A. S.	On some Remains of Fossil Fishes from the Rhætic Beds of the Spinney Hills, Leicestershire	Leicester Lit. Phil. Soc.	*Trans.*	XI.	18	1889
" "	Note on a Species of *Pholidophorus* from the Rhætic Paper Shales of Wigston	" "	"	"	22	"
Worsley-Benison, H. W. S.	On the Power of Movement in Plants	Croydon M. N. H. C.	*Proc. and Trans.*	3	138	1889
Wooton, F. W.	The Land and Freshwater Shells of Cardiff	Cardiff Nat. Soc.	*Report and Trans.*	XX.	32	1888

Section E.—GEOGRAPHY.

Name of Author	Title of Paper	Abbreviated Title of Society	Title of Publication	Volume or Part	Page	Published
Cadell, H. M.	The Utilisation of Waste Lands	R. Scot. Geog. Soc.[1]	*Magazine*	IV.	366	1888
Editorial	Glen Doll	" "	"	"	380	"
Gudgeon, Hon. E. B.	Liberia	Manch. Geog. Soc.	*Journal*	4	233	1889
Mackenzie, Rev. J.	Austral Africa: Extension of British Influence in Trans-colonial Territories	" "	"	"	201	"
Manchester, Bp. of	Victoria	" "	"	"	38	"
Mill, Dr. H. R.	Sea Temperatures on the Continental Shelf	R. Scot. Geog. Soc.	*Magazine*	IV.	544	1888
Milner, G.	Local Geography: The Glen Morton Boggart Hole Clough	Manch. Geog. Soc.	*Journal*	4	174	1889

Murray, Dr. J.	On the Effects of Wind on the Distribution of Temperature in the Sea and Freshwater Lochs of the West of Scotland	R. Scot. Geog. Soc.	*Magazine*	IV.	345	1888
Newbigging, T.	The Heart of Europe as viewed from a Railway Train, with Notes of a Visit to Constantinople and other places in the Ottoman Empire	Manch. Geog. Soc.	*Journal*	4	14	1889
O'Neill, H. E.	Notes on the Nyassa Region of East Africa	,, ,,	,,	,,	87	,,
Riddle, W. W.	Cruise in Central American Waters. San Juan and the Filibuster Walker	,, ,,	,,	,,	104	,,
Rippon, J.	Formosa	,, ,,	,,	,,	169	,,
Sowerbutts, E.	Antarctic Research: its History and Scientific Value	,, ,,	,,	,,	125	,,
Stevenson, J.	The Arabs in Central Africa	,, ,,	,,	,,	72	,,
Various	The Geographical Bibliography of the Salford, Liverpool, and Manchester Free Libraries	,, ,,	,,	,,	104, 113,141	,,
,,	Analysis of the chief contents of a large number of English and Foreign Geographical Journals for 1887	,, ,,	,,	,,	302	,,
,,	Ditto, for 1888	,, ,,	,,	,,	—	,,
Wakefield, Rev. T.	A recent Journey from Lamu to Golbanti in the Galla Country	,, ,,	,,	,,	1	,,

[1] Only the titles of papers bearing on Scottish geography are given by the R. Scot. Geog. Soc.

Section F.—Economic Science and Statistics.

Barrington, R. M.	The Drought of 1887, and some of its Effects on Irish Agriculture	Stat. Soc. Ireland	*Journal*	IX.	223	1889
Bastable, C. F.	Homestead Laws	,, ,,	,,	,,	209	,,
,, ,,	Emigration and Immigration	,, ,,	,,	,,	300	,,
Blackstock, W. S.	Teaching of Natural Science in Public Schools.	E. Scot. Union	*Proc.*	For 1888	7	,,
Brett, Dr. A. T.	On Fish Fatality in the River Colne at Watford	Herts. N. H. Soc.	*Trans.*	V.	93	1888
Broadfield, E. J.	Elementary Education and the Act of 1870	Manch. Stat. Soc.	,,	For 1888-89	51	1889
Bruce, J. T.	On the Collection and Use of Local Statistics	Birm. Phil. Soc.	*Proc.*	VI.	58	—
Cherry, A. H.	Some Economic Aspects of Banking	Manch. Stat. Soc.	*Trans.*	For 1888-89	31	1889
Cherry, R. R.	Decimal Money	Stat. Soc. Ireland	*Journal*	IX.	292	,,
Connolly, T.	The Story of the North American Fisheries	,, ,,	,,	,,	248	,,

Section F.—Economic Science and Statistics (*continued*).

Name of Author	Title of Paper	Abbreviated Title of Society	Title of Publication	Volume or Part	Page	Pub-lished
Darbishire, C. H. .	Piece Work in the Manufacture of Plant and Machinery, and in the Construction of Ordinary Works	Liv'pool E. Soc. . .	*Trans.* . . .	VIII.	113	1888
Eason, C., jun. .	The Present Position of the National Finances .	Stat. Soc. Ireland . .	*Journal* . .	IX.	261	1889
Everett, Prof. J. D.	Reminiscences of the International Shorthand Congress	Belfast N. H. Phil. Soc. .	*Report and Proc.*	For 1888	31	1888
Fielden, J. C. .	State-directed Colonisation and Emigration .	Manch. Geog. Soc. . .	*Journal* . .	4	129	1889
Grimshaw, T. W. .	A Statistical Survey of Ireland from 1840 to 1888. (Opening Address, Session 1888–89.)	Stat. Soc. Ireland . .	,, . . .	IX.	321	,,
Guthrie, E. . .	Inaugural Address	Manch. Stat. Soc. . .	*Trans.* . . .	For 1888-89	1	,,
Houldsworth, Sir W. H.	Colonisation	,, ,, . .	,, . . .	,,	17	,,
Kirlew, G. R. .	Facts and Figures relating to School Children .	,, ,, . .	,, . . .	,,	43	,,
Knowles, J. . .	On the Coal Trade	Manch. Geol. Soc. . .	,, . . .	XX.	42	1888
O'Brien, M. . .	Sliding Scales for Rent Value and Fair Rents—Annual and Capital Value	Stat. Soc. Ireland . .	*Journal* . .	IX.	278	1889
,, ,, .	Note on the Operations of some Swiss Local Banks	,, ,, . .	,, . . .	,,	316	,,
Phythian, J. E. .	The Manchester Art Museum	Manch. Geog. Soc. .	,, . . .	4	137	,,
Ripon, the Marquis of	On the future Extension of the Society . .	Yorks. Geol. Poly. Soc. .	*Proc.* . . .	XI.	114	,,
Roscoe, Sir H. E. .	Some Phases of Technical Education . .	Manch. Stat. Soc. . .	*Trans.* . . .	For 1888-89	69	,,
Russell, Dr. J. B. .	On the 'Ticketed' Houses of Glasgow, with an Interrogation of the Facts for Evidence towards the Amelioration of the Lives of their Occupants	Glasgow Phil. Soc. . .	*Proc.* . . .	XX.	—	—
Scott, F. . .	The Condition and Occupations of the People of Manchester and Salford	Manch. Stat. Soc. . .	*Trans.* . . .	For 1888-89	83	1889
Tapscott, R. L. .	A short Railway Journey in India . . .	Liv'pool E. Soc. . .	,, . . .	VIII.	106	1888
Ward, J., and J. G. Sankey	The Simpson Memorial Institute: the Building and the Work of the Institution	Manch. Geog. Soc. . .	*Journal* . .	4	172	1889

Section G.—Mechanical Science.

Anderson, T. S.	The Telephone: its Application and Developments	Cornw. Min. Assoc. Inst.	*Trans.*	II.	—	1889
Bennett, E. J.	Modern Crushing and Concentrating Machinery	" "	"	"	—	"
Bochet, H.	Experimental Determination of the Results of the Working of a new Fan (Capell), and the consequences deduced from these results	Chesterf. Mid. Count. Inst.	"	XVII.	190	"
Bramall, H.	On the Effects of Roburite Fumes	Manch. Geol. Soc.	"	XX.	158	"
Brightmore, A. W.	The Flow of Water	Liv'pool E. Soc.	"	VIII.	1	1888
Burrows, J. S.	Notes on working with the Edison Swan Lamp	Manch. Geol. Soc.	"	XX.	71	1889
Campbell, J. J.	Compound Engines for Atlantic Steam Navigation	Liv'pool E. Soc.	"	VIII.	56	1888
Capell, Rev. G. M.	Mechanical Ventilation of Collieries, with a description of a new form of enclosed Mine Ventilator	Chesterf. Mid. Count. Inst.	"	XVII.	174	1889
Committee	Federation of Mining Institutes	N. Eng. Inst.	"	37	155	—
"	Mechanical Ventilators	" "	"	"	181	—
Cox, L. C.	A double-acting Wedge for getting Coal (Cox's patent)	Chesterf. Mid. Count. Inst.	"	XVII.	108	1888
Darbishire, C. H.	Sewer Ventilation	Liv'pool E. Soc.	"	VIII.	13	"
Fletcher, H.	On the Effects of Goaf Stowing on sudden Issues of Gas and on Ventilation	Manch. Geol. Soc.	"	XX.	173	1889
Grundy, J.	On the Premature Explosions of Gunpowder	" "	"	"	84	"
Henderson, J.	Telpherage	Cornw. Min. Assoc. Inst.	"	II.	—	"
Hilton, J.	On the Use of Roburite in Coal Mines	Manch. Geol. Soc.	"	XX.	92	"
Hollingworth, G. H.	The Phœnix Safety Lamp	" "	"	"	198	"
Hudleston, F.	The Coal Shipping Appliances of the Port of Liverpool	Liv'pool E. Soc.	"	VIII.	75	1888
Hunter, J.	Charles Pit, Flaggy Creek, Pit Heading: Description of Survey	N. Eng. Inst.	"	38	13	—
Lean, J.	Tunnelling through various Strata	Bristol Nat. Soc.	*Proc.*	V.	147	—
Marley, J.	Presidential Address	N. Eng. Inst.	*Trans.*	38	29	—
Marshall, W. P.	On the Successful Use of Oil to calm Rough Seas	Birm. N. H. M. Soc.	*Mid. Naturalist*	11	170	1888

Section G.—MECHANICAL SCIENCE (*continued*).

Name of Author	Title of Paper	Abbreviated Title of Society	Title of Publication	Volume or Part	Page	Pub-lished
Metcalfe, A. W.	Continuous Railway Brakes	Bristol Nat. Soc.	*Proc.*	V.	168	—
Meyer, G. and W. J. Bird	The Use of Iron Supports in the Main Roads of Mines instead of Masonry or Timbering	N. Eng. Inst.	*Trans.*	37	135	—
Morison, J.	The Danger attending the use of light Mineral Oils for lubricating Air-compressing Machinery	,, ,,	,,	38	3	—
Platt, S. S.	Sewers and Drains (Ancient and Modern)	Rochdale Lit. Sci. Soc.	,,	I.	28	1888
Pooley, H., jun.	Automatic Weighing Machines	Liv'pool E. Soc.	,,	VIII.	96	,,
Richardson, C.	The Arch	Bristol Nat. Soc.	*Proc.*	V.	95	—
Sherratt, W.	Water Supply to large Towns	Manch. Geog. Soc.	*Journal*	4	58	1889
Simpson, H. H.	Future Engineering	Bristol Nat. Soc.	*Proc.*	V.	199	—
Spencer, C. J.	On the Setting of Steam Boilers	,, ,,	,,	,,	133	—
Steavenson, A. L.	On the Introduction of Steel Supports for the Maintenance of Main Roads in the Mines of Cleveland	N. Eng. Inst	*Trans.*	37	221	—
Sturgeon, J.	The Birmingham Compressed Air Power Scheme.	Liv'pool E. Soc.	,,	VIII.	28	1888
Shaw, Prof. H. S. H.	Testing of Steam Engines	,, ,,	,,	,,	42	,,
Swete, O. R.	A new Miner's Electric Safety Lamp	Manch. Geol. Soc.	,,	XX.	60	1889
Swiney, J. H. H.	Mechanical Removal of Deposit from Water Mains, as carried out at Omagh in 1887	Belfast N. H. Phil. Soc.	*Report and Proc.*	For 1888	61	1888
Thomson, J. H.	The Blackwall Artesian Well, Queensland	Manch. Geog. Soc.	*Journal*	4	168	1889
Townsend, C. H.	Art and Architecture: their relation and subordination in Engineering Works	Liv'pool E. Soc.	*Trans.*	VIII.	85	1888
Vaudrey, J. C.	Notes on Practical Electricity, especially regarding its use as an Illuminant	,, ,,	,,	,,	43	,,
Webster, J. J.	Retiring Presidential Address	,, ,,	,,	,,	118	,,
Williams, R. H.	Proper and Improper Treatment of Steam Boilers	Corn. Min. Assoc. Inst.	,,	II.	—	1889
Winstanley-Wallis, T. M.	Electric Lighting and Transmission of Power in Mining	Chesterf. Mid. Count. Inst.	,,	XVIII.	242	,,

Section H.—ANTHROPOLOGY.

Anonymous . .	On the Investigation of British Barrows, near Hunmanby, in the East Riding	Yorks. Geol. Poly. Soc. .	*Proc.* . . .	XI.	91	1889
Bradbury, Dr. .	The Cairn, Gretch Veg	I. of Man N. H. A. Soc.	*Yn Lioar Manninagh*	I.	49A	"
Browne, M. . .	Evidences of the Antiquity of Man in Leicestershire	Leicester Lit. Phil. Soc. .	*Trans.* . . .	IX.	7	1888
Buckland, Miss A. W.	The Monument known as King Orry's Grave compared with Tumuli in Gloucestershire	I. of Man N. H. A. Soc. .	*Yn Lioar Manninagh*	I.	42A	1889
Cole, Rev. E. M. .	Notes on the Ancient Entrenchments in the Neighbourhood of Wetwang	Yorks. Geol. Poly. Soc. .	*Proc.* . . .	XI.	45	"
" " .	On a Lake Dwelling recently discovered at Preston	" " .	" . . .	"	90	"
" " .	A Lake Dwelling in Lancashire . . .	Yorks. Nat. Union . .	*The Naturalist* .	For 1888	360	1888
Committee, The .	Report on Excavations near Llantwit-Major .	Cardiff Nat. Soc. . .	*Report and Trans.*	XX.	49	1889
Crellin, Miss A. M.	On the Opening of a Burial Mound, Michael .	I. of Man N. H. A. Soc. .	*Yn Lioar Manninagh*	I.	11A	"
Davis, J. W. .	On the Lake Dwellings in East Yorkshire .	Yorks. Geol. Poly. Soc. .	*Proc.* . . .	XI.	101	"
Fraser, J. . .	Note on an Ancient Spear Head . . .	Inverness Sci. Soc. . .	*Trans.* . . .	II.	297	—
" " . .	Stone Circles of Strathnairn	" " . .	" . . .	"	360	—
Hare, Prof. A. W.	Facial Expression	Belfast N. H. Phil. Soc. .	*Report and Proc.*	For 1888	65	1888
Heape, C. . .	Weapons of Savages, their Development and Distribution	Rochdale Lit. Sci. Soc. .	*Trans.* . . .	I.	40	"
" " . .	Ornament as applied to Weapons by the Races of Oceania	" " .	" . . .	"	93	"
Heron, J. . .	Report of the Stapenhill Explorations . .	Burt. N. H. A. Soc. .	" . . .	"	156	1889
Hicks, Dr. H. .	Prehistoric Man in Britain	Herts. N. H. Soc. . .	" . . .	V.	147	"
Jones, Rev. E. .	On the recent Exploration of a Cave at Elbolton, near Thorpe	Yorks. Geol. Poly. Soc. .	*Proc.* . . .	XI.	86	"
Kermode, P. M. C.	Tumuli on Snaefell and Skyhill . . .	I. of Man N. H. A. Soc. .	*Yn Lioar Manninagh*	I.	27	"
" "	On an Ancient Canoe discovered at Ballakaighen, German	" " .	" " .	"	36	"
Knowles, T. . .	The Source of the Modern English (Roman) Alphabet	Burt. N. H. A. Soc. .	*Trans.* . . .	"	68	"
Lach-Szyrma, Rev. W. S.	The Cornish and Manx Languages historically compared	Penz. N. H. A. Soc. .	*Report and Trans.*	III.	77	"

Section II.—ANTHROPOLOGY (*continued*).

Name of Author	Title of Paper	Abbreviated Title of Society	Title of Publication	Volume or Part	Page	Pub-lished
Laver, H.	Flint Implements at Walton-on-Naze and Lexden, Essex	Essex F. C.	*Essex Naturalist*	II.	187	1888
" "	Fifty Years ago in Essex	" "	" "	III.	—	1889
Law, R., and J. Horsfall	An Account of small Flint Implements found beneath Peat on the Pennine Chain between Huddersfield and Oldham	Manch. Geol. Soc.	*Trans.*	XIX.	599	1888
Lockwood, F. W.	Ancient Canoes found in Lough Mourne	Belfast Nat. F. C.	*Report and Proc.*	III.	52	"
Lovett, E.	Notes on the Origin and Development of Flint and Stone Implements	Holmesdale N. H. C.	*Proc.*	For 1886-87	39	"
March, Dr. H. C.	Introductory Address	Rochdale Lit. Sci. Soc.	*Trans.*	I.	89	"
Miller, H.	A Well in the Roman Wall	Inverness Sci. Soc.	"	II.	53	—
Milligan, S. F.	The Forts of Erin from the Firbolg to the Norman	Belfast N. H. Phil. Soc.	*Report and Proc.*	For 1888	54	1888
" "	An Ogham Inscription in the County of Tyrone	" "	" "	"	64	"
Morrison, Rev. J.	Archæological Finds in the East of Moray	Inverness Sci. Soc.	*Trans.*	II.	36	—
Pengelly, W.	Recent Researches in Bench Cavern, Brixham, Devon	Edinb. Geol. Soc.	"	V.	507	1888
Plowman, T. F.	The Divining Rod	Bath N. H. A. F. C.	*Proc.*	VI.	411	1889
Roeder, C.	On a new Archæological Discovery on the Ship Canal at Sticking Island	Manch. Geol. Soc.	*Trans.*	XX.	204	"
Ross, A.	Old Inverness	Inverness Sci. Soc.	"	II.	64	—
" "	The Nile Valley, its Tombs and Temples	" "	"	"	298	—
Ross, J.	Urquhart Castle	" "	"	"	30	—
Scott - Moncrief, Sheriff	The Antiquities of Banff	" "	"	"	328	—
Smith, Rev. T. N. H.	Weights and Measures of Pupils	Marlb. Coll. N. H. Soc.	*Report*	37	201	1889
Smith, W. G.	Neolithic and Palæolithic Scrapers, replaced and reworked	Essex F. C.	*Essex Naturalist*	II.	67	1888
Stewart, Rev. Dr.	Ballachulish	Inverness Sci. Soc.	*Trans.*	"	21	—
Tannahill, T. F.	Prehistoric Man	Rochester N. C.	*Roch. Naturalist*	1	345	1888
Wallace, T.	Archæological Remains in the Engie, Banffshire	Inverness Sci. Soc.	*Trans.*	II.	274	—
" "	Archæological Notes	" "	"	"	307	—

Fourth Report of the Committee, consisting of Professors FITZGERALD (*Chairman*), ARMSTRONG *and* O. J. LODGE (*Secretaries*), Sir WILLIAM THOMSON, Lord RAYLEIGH, J. J. THOMSON, SCHUSTER, POYNTING, CRUM BROWN, RAMSAY, FRANKLAND, TILDEN, HARTLEY, S. P. THOMPSON, McLEOD, ROBERTS-AUSTEN, RÜCKER, REINOLD, CAREY FOSTER, *and* H. B. DIXON, Captain ABNEY, Drs. GLADSTONE, HOPKINSON, *and* FLEMING, *and* Messrs. CROOKES, SHELFORD BIDWELL, W. N. SHAW, J. LARMOR, J. T. BOTTOMLEY, R. T. GLAZEBROOK, J. BROWN, E. J. LOVE, *and* JOHN M. THOMSON, *appointed for the purpose of considering the subject of Electrolysis in its Physical and Chemical Bearings.*

DURING the past year the following publications have been circulated among the members of the Electrolysis Committee and among a few others.

1. The Report of the Committee presented at Bath, together with the appended papers.

2. Some copies of a sketch of the electrical proceedings of Section A. at Bath, drawn up by the Physical Secretary.

3. A reply by Dr. Arrhenius to some criticisms of Professor Armstrong regarding his theory, which were annexed to last year's Report.

4. A translation by Professor Ramsay of some letters from Professor Ostwald regarding an experiment in the dissociation theory of Electrolysis published by him.

5. Some criticisms by Mr. John Brown and by the Secretary regarding this experiment of Professor Ostwald.

6. An explanation by the Secretary of a partial misunderstanding he had made in respect of this experiment.

7. A reply by Professor Ostwald to Messrs. Brown and Lodge.

8. Some copies of a paper communicated by Mr. John Brown to the Committee, and by them sent to the Philosophical Magazine on the subject of Helmholtz's views regarding dropping electrodes, and the cause of the E.M.F. when mercury drips from a funnel into an electrolyte.

In addition to these, Professor A. M. Worthington has favoured the Committee with a paper On the Discharge of Electrification by Flames, which is to be read at the present meeting, and Mr. W. N. Shaw is communicating the first part of his report on the present state of our knowledge of Electrolysis.

The money expended on printing has been kept low this year by the method adopted of publishing usually in the 'Electrician' and purchasing a certain number of separate copies for the use of the Committee. Also by somewhat reducing the range of circulation.

The expenditure has been: Printing, 3*l.* 16s. 3d.; postage and carriage, 1*l.* 19s. 9d.; total, 5*l.* 16s. It is proposed to ask for reappointment with the lapsed portion of the grant of 15*l.* renewed.

Remarks by Professor ARMSTRONG.

In the past, as in the previous year, the Clausius dissociation hypothesis of electrolysis has alone secured attention: its advocates, Ostwald especially, have in a perfectly logical manner, without hesitation, extended its application to explain

phenomena such as are involved in the formation of salts generally; and it has become more than ever obvious that the solution of very many of the fundamental problems of chemistry must originate in that of electrolysis. As yet, however, no philosophical attempt has been made to discuss the subject except from the one point of view, or even to consider the objections which have been urged against the dissociation hypothesis. I have recently dwelt on the difficulty of accepting the conclusion that the solvent does not play an active part in a 'Note on the Determination of the Molecular Weight of Substances in Solution, especially Colloids,' in the 'Proc. Chem. Soc.' of June 20th, 1889, p. 109, to which I may refer.

In my reply to Arrhenius in the last Report I spoke of Fitzpatrick's results as 'obtained with "commercial" alcohol,' adding, 'it is very important that *pure* alcoholic solutions should be examined.' It is pointed out to me that this may be held to imply that Fitzpatrick had used very impure alcohol; but nothing of the kind was intended by me: Fitzpatrick, I know, used the best alcohol that could be bought, and carefully dried it. No substance is more difficult to purify than alcohol, however, and *pure* alcohol is probably unobtainable: what I desired to imply was that experiments should be made with alcohol which had been purified with every possible precaution to the ultimate attainable limit—this has never been done.

The *Zeitschrift für Physikalische Chemie*, 1889, p. 236, contains a very brief reference to the last Report of this Committee, by the Editor, Professor Ostwald, who obviously entirely fails to appreciate the force of, or even to understand, my objections, and who unfortunately adopts the off-hand tone of conscious certainty of the editorial 'We,' which hitherto has been altogether absent from scientific discussions, but is too frequently noticeable in the journal in question. In this notice there is the following phrase: 'Zum Schluss wird die Annahme, dass in galvanischen Elementen die chemische Energie völlig in electrische Energie übergehe, trotz der vielen gegenteiligen Erfahrungen, aufrecht zu halten versucht.' It would have conduced to the proper understanding of this criticism if Professor Ostwald had quoted, however briefly, the 'gegenteilige Erfahrungen.' I presume he refers to the works of Braun and of Wright and his coadjutors; but I have already shown that their conclusions cannot be regarded as satisfactory. Meanwhile an important paper by Professor E. F. Herroun, 'On the Divergence of Electromotive Forces from Thermochemical Data,' has appeared in the 'Phil. Mag.' (1889, 27, 209), in which it is clearly shown that in calculating the E.M.F. corresponding to a chemical change from thermal values, although in some cases—that of zinc, for example—the heat of dissolution of the metal in the solution actually used is to be introduced into the calculation, in other cases—*e.g.*, that of silver—the heat of formation of the anhydrous salt is to be chosen. This is a most valuable observation, and is in accordance with the statement in my reply to Arrhenius last year, that 'R in the formula $C = E\ R$ was never regarded by me as simply the resistance of the *solution* in which the interaction takes place; it is the resistance of the *circuit* in which interaction occurs. This latter may be quite different from the former, as, of a number of substances in solution, some only may be capable of entering into the true circuit of change.' It has recently been observed that considerable cooling takes place during the discharge of Faure secondary cells,[1] and this would point to the fact that not the dilute acid present in the cell, but a lower hydrate or $H_2\ SO_4$ itself, is concerned in the change—*i.e.*, operates in forming sulphate; and that the cooling results from the dissociation of the hydrated acid. We must therefore picture to ourselves the possibility of two sets of actions taking place in certain cells—one set within the circuit, and contributing to the E.M.F.; another set without the circuit, and not contributing to the E.M.F. We must picture to ourselves, in fact, a set of molecules swimming up from within the solution to the surface of the electrode, and there interacting with the latter; and thereafter a product or products returning into the solution and becoming hydrated: as the dehydration and

[1] See a paper 'On the Inherent Defects of Lead Secondary Batteries,' by Dr. Louis Duncan and H. Wiegand, read before the American Institute of Electrical Engineers, New York, May 22, 1889; printed in the *Electrical World*, June 15.

hydration both occur outside the true circuit of change, they only affect the temperature of the cell, and have but an indirect and slight influence on the E.M.F. I therefore repeat that 'I venture to think that up to the present no experimental disproof of Sir William Thomson's generalisation has been given.' In other words, we may calculate the E.M.F. of a cell from a knowledge of the heat disturbances corresponding to the various changes which occur in it, providing only that we know accurately what are the changes which occur in the circuit; in cases in which the found and calculated value do not agree, we may fairly conclude that we have not accurately realised what the changes are, and in this way the determination of E.M.F. may be expected to afford most important aid in the study of chemical change.

A discovery in electrolysis of much interest to chemists is that made by Warburg and Tegetmeier, that rock crystal conducts electrolytically, but in the direction of the principal axis alone; they conclude that conductivity is conditioned by the presence of sodium in the form of sodium silicate, and they consider that, according to the Clausius theory of electrolysis, this fact of electrolytic conduction only taking place in the direction of the principal axis would tend to the inference that in the case of rock crystal not traversed by an electric current the interchange of atoms between the molecules can only take place, at any rate to a sensible extent, in the direction of the principal axis. It may, however, be suggested that probably in the original formation of the crystal the impurity became included only in planes in the direction of the principal axis.

APPENDIX.

On the Discharge of Electrification by Flames. By A. M. WORTHINGTON, *Royal Naval Engineering College, Devonport.*

1. It is well known that an ebonite or glass rod that has been electrified by rubbing is immediately and completely discharged by passing it either through or over a flame, for example, of a Bunsen burner. It is, I think, less well known, though the observation seems to have been made by Priestley [1], that the discharge takes place with apparently equal rapidity if the rod be held at the side of, or even below, the flame at a distance of, say, 5 cm. This is the case whether the Bunsen burner be insulated or not, and it is equally true of a candle flame.

A red-hot piece of iron or copper discharges a rubbed rod that is held very near it, whether above, below, or at the side. If the rubbed rod be a very thick one, say of 3 cm. diameter, it is not at once discharged on the side remote from the flame. If held at a distance of, say, 8 cm. from the flame, a rubbed rod of 8 or 10 mm. in diameter is less rapidly discharged than at the nearer distance, but is still discharged in a few seconds; but the rate of discharge diminishes very rapidly as the distance from the flame is increased.

2. If a plate of metal, insulated or uninsulated, or a piece of wire gauze of even coarse texture be held with one side close to the flame and then a charged rod be brought up to the other side of the plate, no discharge takes place. A plate of glass or ebonite held in the same way between the flame and the rod equally prevents discharge.

But when the charged rod and glass plate are withdrawn together from the neighbourhood of the flame, then the glass plate is found to be charged on the side nearest the flame with a charge of opposite sign to that of the charge on the rod.

3. The above experimental facts, which will be more or less familiar to physicists, are here cited in order that the significance may be perceived of the experiment that will next be described.

Being under the impression, which I fancy is pretty general, that the flame and the surrounding air constituted a sort of conductor which removed the charge of

[1] An historical *résumé* of early observations on the electrical properties of flames is given in the paper of Peter Riess, 'Ueber die elektrischen Eigenschaften brennender Körper,' *Pogg. Ann.*, vol. lxi., 1844.

the rod, as it were, by licking its surface, or, perhaps, as Van Rees[1] suggested, by throwing off under the influence of the charged rod, finite portions of itself charged inductively with the opposite electrification, I made the experiment of surrounding the rod by a strong blast of air from a foot blow-pipe, expecting thereby to prevent the discharge by blowing away the conductive air before it reached the surface of the rod; but I found that the interposed blast of air, however violent, was quite without influence on the discharge, which took place across it with perfect facility when the flame was approached. It should be mentioned that the blast alone without the flame was quite incompetent to discharge the rod.

4. This observation makes it, I think, quite clear that the discharge is effected, not by the flame or mass of air round it acting as a whole, but by a molecular action, the velocity of propagation of which is very great compared with the velocity of the air in the blast.

5. All the phenomena above mentioned, and others to which I shall shortly allude, appear to be explainable as follows, and, so far as I can see, in no other way.

The flame contains a large number of dissociated atoms, each with + ve or − ve atomic charges. A charged body, such as the rod, attracts towards itself those of opposite sign and repels those of the same sign, and under this directive influence an electrolytic action is propagated across the intervening air, the discharge being effected by the liberation of free atoms on the surface of the body. When a glass or ebonite plate is interposed this liberation takes place on the surface nearest the flame, and the plate is thereby charged.

The shortness of the mean free path of molecules, and presumably also of atoms in the air at atmospheric pressure, and the incompetence, so far as I can observe, of even the most violent interposed blast of air to affect the discharge seems to preclude the supposition that the free atoms which reach the rod are those which were originally present in the flame.

The flow in the opposite direction of atoms bearing charges of the same sign as that of the rod was put in evidence by the experiment of placing a glass or ebonite plate near to an insulated flame, and then bringing up a charged rod to the opposite side of the flame, when the plate was found to receive a charge of the same sign as that of the rod. Care must be taken to withdraw the plate as the rod is approached, otherwise it also will be discharged. A variation of this experiment is to make the like charge flow on to and charge an electroscope by means of an interposed insulated flame. For some experiments of this kind a metallic conductor connected with an electrical machine by which the charge may be maintained was found more convenient than the charged rod.

6. When a charged insulated body is discharged by the proximity of an insulated flame it is not at once obvious how the equal and opposite charge on the walls of the room in which the experiment is made, has been neutralised. I imagine that this must be effected by an electrolytic discharge through the air between the flame and the walls, originating in the excess of atoms charged similarly to the body, which are left over when the charge on the body is neutralised, and on which the lines of force proceeding inwards from the walls of the room now terminate. Thus the discharge involves the shifting of the ends of these lines of force from the original rigid body on to atoms which are free to move under the directive stress.

7. If this explanation of the discharge by a flame is correct, it should follow that discharge should be facilitated whenever free atoms are present, and I found on trial that when a rubbed ebonite rod was placed transversely in the path of the spark discharge, between the terminals of a Wimshurst machine, it lost a large amount of its charge at the passage of each spark, and was soon completely discharged.

This appears to be a special instance of the phenomenon brought into notice by Dr. Schuster of a small electromotive force producing a current when the electrolyte has been broken down by a greater electromotive force.

8. For investigation of the temperature at which a piece of hot metal begins to act like a flame in producing discharge, a storage cell was insulated and connected

[1] *Pogg. Ann.*, vol. lxxiv., p. 379, 1849.

with an electroscope, and charged statically; the terminals were then joined by a strip of thin platinum foil, whose length could be varied at will by means of insulating handles. The strip when shortened became more and more heated by the increased current, but only when a red heat was reached did I observe that the statical charge of the cell began to escape.

This would seem to show that (in daylight at any rate) dissociated atoms are not found at the surface of the metal at a temperature below that of a red heat.

The rate of escape of charge was much increased by holding an earth-connected conductor near to the red-hot platinum. This would increase the density of charge at the surface of the platinum, and therefore the electric force at the surface, *i.e.*, the directive force on the free atoms.

9. By hanging side by side, in a large Bunsen flame, a sheet of copper and a sheet of platinum, which were connected outside the flame by a wire having in circuit a galvanometer of about 200 ohms resistance, a feeble current of about 2×10^{-6} ampères was obtained, the flame appearing to act as an electrolyte of very high resistance through which the current passed from the more oxidizable copper to the less oxidizable platinum.

When, however, two sheets of platinum were hung in the flame so that one just touched the outside, while the other bisected the flame, a current of about the same magnitude was obtained, and in either direction at will, according to the relative positions of the plates in the flames, and the observation of Messrs. Elster and Geitel was confirmed, that the outer mantle of the flame is at a higher potential than the interior of the flame. The effect of this seemed to over-ride and obscure any effect due to the difference of the material of the two plates.

I have not been able to obtain any more direct experimental evidence that there is an excess of + ve atoms on the outside, and of – ve on the inside of the flame.

10. The only experiment mentioned in this paper that I can suppose to be new is that of the air-blast; but in the light of this, the significance of the other experiments cited seems considerably changed, and the inference that a charge of either sign, indistinguishable from the charges that are produced by friction, may be obtained on a non-conductor in air, by the liberation of free atoms on its surface, is not at present so familiar that any excuse seems required for emphasising it.

Note.—Professor Poynting has suggested to me since the above was written, that the charges of the dissociated atoms might be so great and their masses so small, that the acceleration communicated under the electric stress would suffice to enable the original atoms present in the flame to traverse the air-blast.

Report of the Committee, consisting of General Festing (*Chairman*), Dr. H. E. Armstrong (*Secretary*), Captain Abney, *and* Professor W. N. Hartley, *on the Absorption Spectra of Pure Compounds.*

During the past year the research has not progressed so rapidly as it was hoped would have been the case, owing to various causes; but a considerable advance has been made in the methods to be employed in the research. Considerable difficulty was encountered in devising the method to employ with the various liquids, and a long series of observations were undertaken with the object of ascertaining what was the really most practicable plan. It was hoped at one time that a modified diffraction method might have been adopted, but experiment showed that although such a method was not impossible, it was impracticable. Eventually a double hollow prism was found to give the best results, with a completely different arrangement of collimator and lens to that usually adopted. It would be premature to describe the apparatus in detail. This will be communicated when the results from the photographs of the compounds already taken have been tabulated.

Professor Armstrong has prepared a certain number of a series of compounds which it will be of interest to investigate; and it is hoped that at the next meeting the Committee will be able to report more fully on the points which they have been called upon to investigate.

The Committee request that they may be reappointed for another year.

Second Report of the Committee, consisting of Professor H. E. ARMSTRONG, Professor W. R. DUNSTAN (*Secretary*), Dr. J. H. GLADSTONE, Mr. A. G. VERNON HARCOURT, Professor H. M'LEOD, Professor MELDOLA, Mr. PATTISON MUIR, Sir HENRY E. ROSCOE, Dr. W. J. RUSSELL (*Chairman*), Mr. W. A. SHENSTONE, Professor SMITHELLS, *and* Mr. STALLARD, *appointed for the purpose of inquiring into and reporting upon the present methods of teaching Chemistry.*

IN a report presented to the Bath Meeting the Committee gave an account of the replies they had received to a letter addressed to the head masters of schools in which elementary chemistry is taught. In this letter the Committee had asked for a report on the chemical teaching, and also for a statement as to the methods which had been found to render the teaching most effective as a mental training. In commenting on these replies the Committee pointed out that the evidence which had been collected was conclusive in showing that much of the teaching of elementary chemistry is far from satisfactory, and needs to be considerably modified if it is to effect that valuable mental discipline which science teaching can afford.

The Committee are convinced that the high educational value of instruction in physical science has never been exhibited to its full advantage in most of our educational institutions. Nevertheless there exists already a considerable body of experience which proves that there is no more effective and attractive method of training the logical faculties than that which is afforded by a properly arranged course of instruction in physical science; by no other means are the powers of accurately ascertaining facts, and of drawing correct inferences from them, so surely developed as they are by the study of this subject.

Since the last meeting the Committee have been actively engaged in discussing the lines which a course of elementary instruction in chemistry should follow. The Committee were the more inclined to offer suggestions of their own, since they had learnt from the replies made to their letter of last year, by teachers in many of our well-known schools, that not only is the necessity for the adoption of improved methods fully recognised, but that teachers are anxious to receive advice and assistance in introducing them.

It cannot be too strongly insisted that elementary physical science should be taught from the first as a branch of mental education, and not mainly as useful knowledge. It is a subject which, when taught with this object in view, is capable of developing mental qualities that are not aroused, and indeed are frequently deadened, by the exclusive study of languages, history, and mathematics. In order that the study of physical science may effect this mental education, it is necessary that it should be employed to illustrate the scientific method in investigating nature, by means of observation, experiment, and reasoning

with the aid of hypothesis; the learners should be put in the attitude of discoverers, and should themselves be made to perform many of the experiments. The lessons ought to have reference to subjects which can be readily understood by children, and illustrations should be selected from objects and operations that are familiar to them in everyday life. Chemistry is particularly well adapted for affording this kind of instruction, and the Committee are of opinion that a course which is mainly chemical will be most useful in developing logical habits of thought.

Chemical inquiry involves, however, the use of various physical processes, and these are themselves of great value from the point of view from which the instruction is being given. It is also of great importance that the learners should become acquainted with the characteristic instrument of physical science, viz., measurement, and therefore quantitative processes should be largely made use of.

Having agreed as to the general principles on which a scheme of elementary instruction in chemistry should depend, the Committee gladly accepted the offer of Professor Armstrong to draw up an account of such a scheme in sufficient detail to serve as a guide to those who have to provide such teaching. Without pledging themselves to accept all its details, the Committee consider that the scheme which Professor Armstrong has prepared (see pp. 229–250) is in general accordance with their views as to what should constitute a course of elementary instruction in physical science.

With regard to the manner in which the scheme should be carried out, the Committee wish to lay stress on the following points. In order that the plan shall produce its full educational effect, the instruction should be commenced at an early age, and be extended to every child in the school. They do not desire to bring forward physical science as a substitute for any of the other principal subjects of study, but they ask that like these subjects it should be looked upon everywhere as a necessary part of education, and that it should receive a due share of the time devoted to school work. It is well known that at present science-teaching does not generally receive as much time and attention as is given to other studies. This was made clear in the report of the Committee last year. It will be necessary to allot more time to the subject, and to employ a greater number of teachers. A teacher should not be required to give practical instruction to more than from fifteen to twenty pupils at one time, although the classes at lectures and demonstrations might be somewhat larger.

While the scheme now proposed may involve the employment of a larger number of teachers of natural science, on the other hand fittings and apparatus of the simplest description are all that will be absolutely needed, and the cost of maintenance will be relatively small.

The Committee are aware that the course of instruction now suggested is not in conformity with the present requirements of examining bodies. Its general adoption must therefore depend on their co-operation.

Suggestions for a Course of Elementary Instruction in Physical Science. Drawn up by Professor ARMSTRONG.

Although the Committee are ostensibly charged to report as to methods of teaching *chemistry*, chemistry pure and simple is not what is generally required in schools, and therefore the Committee must be prepared to take into consideration and make recommendations for a course of

instruction preliminary to the natural science course proper, which in their opinion affords the most suitable and efficient preparation for later natural science studies.

After the most careful consideration of the question during at least ten years past, and after long holding the opinion that chemistry as usually understood is not the most suitable science subject for school purposes, I am now of opinion that a course which is mainly chemical is not only the best but also the only one possible if we are to secure all the objects aimed at in introducing science teaching into schools. Those objects are essentially: to train boys and girls to use their brains; to train their intelligence; to make them observing and reasoning beings, accurate observers, and accurate thinkers; to teach them to experiment, and that, too, always with an object—more frequently than not with what may be termed a logical object—not for mere descriptive purposes; to gradually inculcate the power of 'doing,' on which Charles Kingsley has laid so much stress, and which undoubtedly is the main factor of success in life. It can scarcely be gainsaid that through chemistry more than through any other branch of natural science it is possible to give precisely that kind of 'practical' training so requisite at the present day, because the student is able to ascertain *by experiment* what are the exact facts and thus to arrive independently at an explanation, whereas in the case of other sciences more often than not the explanation of necessity has to be given by the teacher.

Chemistry as usually taught loses greatly in educational value because pupils are told, more often than not, that 'so and so is the case,' instead of being taught *how it has been found out* that such is the case; indeed, that which has to be proved is usually taken for granted. Practical chemistry has hitherto, as a rule, been interpreted to mean the preparation of a few gases, &c., and the analysis of simple salts. Much useful information may be and is occasionally imparted during the performance of exercises of this kind, but the tendency undoubtedly is for analysis to degenerate into a mechanical drill, and, looking at the question from the practical point of view, and considering what is the general outcome of such teaching, probably we are bound to agree that the results thus far obtained are usually unsatisfactory. The difficulty, however, is to devise a course sufficiently simple both in conception and when carried into practice the cost of which is not too great; but with respect to this item of cost the Committee have to make clear to parents and teachers the claim of natural science to a fair and proportionate share of the total expenditure, which certainly has never yet been granted to it. By the introduction of such studies into the school course a set of faculties are trained which it is all-important to develop, but which hitherto have been allowed to remain dormant, if not to atrophy, through neglect, and which, it is admitted by all competent authorities, cannot possibly be developed by any amount of attention to literary and mathematical studies. It is often not sufficiently clearly stated or understood that the advocates of natural science studies have no desire to displace any of the traditional subjects from the school course, and that all that they ask for is a fair share of the child's time, attention and brains—a share proportionate to the effect which such studies can demonstrably produce in developing the mental faculties of the individual: that, in fact, natural science claims to co-operate and in no sense puts in an appearance as a rival.

STAGE I.—*Lessons on common and familiar objects.*

The first stage of instruction must be one of simple object lessons, but these should have an intimate relation to the child's surroundings, and should be made the pegs on which to hang many a tale. Probably the most satisfactory and practical mode of commencing is to get children to draw up lists of familiar and common objects under various heads, such as

Natural objects.

Things used in building construction.

Things from which household furniture is made or which are in daily use.

Things used as clothing.

Food materials.

The children should be induced to describe these from observation as far as possible; to classify them according to their origin into mineral and animal and vegetable or organic; and occasion should be taken at this stage to give by means of reading lessons and demonstrations as much information as possible about the different things, their origin, how made, and their uses. It is obvious that in this way a great deal of geography and natural history (*Naturkunde*) might be taught in an attractive manner. Geikie's 'Science Primer on Physical Geography' is the type of book which may be worked through with great advantage at this stage.

STAGE II.—*Lessons in measurement.*

This stage should be entered upon as soon as children have learnt the simple rules of arithmetic, and are able to add, subtract, multiply and divide—and to use decimals.

Lineal measurements may be first made, using both an English foot-rule with the inch subdivided in various ways and a metric rule subdivided into millimetres. In this way the relation of the two scales is soon insensibly learnt.

Measurements of rectangular figures and the calculation of their areas may then be made.

After this the use of the balance may be taught, and the relation between the English and French systems may be learnt by weighing the same objects with the two kinds of weights. Use may then be made of the balance in determining the areas of irregular figures by cutting out rectangular and irregular figures from the same cardboard or thin sheet metal, and weighing these, &c.

Solid figures are next studied: a number of cubes made from the same wood having been measured, their volumes are then calculated, and the results thus obtained are compared with those which are obtained on weighing the cubes. The dimensions and weights of cubes made from different woods or other materials are then ascertained, and thus it is observed that different materials differ in *density.* The study of the *relative density* of things generally is then entered upon. The ordinary method is easily learnt and used by children, a suitable bottle being provided by filing a nick down the stopper of a common two-ounce narrow mouth bottle; it may then be shown that the same results are obtained

by the hydrostatic method of weighing in air and water, and it is not difficult to lead children to understand this latter method after they have determined the heights of balancing columns of liquids such as turpentine, water and saturated brine, of which they have previously ascertained the relative density. These hydrostatic experiments are of value at a later stage in considering the effects of atmospheric pressure.

By determining the dimensions of a cube and the weight of the water which it will displace, an opportunity is afforded to point out that if the results are expressed in cubic centimetres and grams respectively, there is a practical agreement between the numbers, and hence, to explain the origin of the metric system of weights and the relationship between its measures and weights; the irrationality of the English system may then be explained.

The relative densities of a large number of common substances having been ascertained, the results may be tabulated and then the value of the data as criteria may be insisted on; as an illustration of their value, quartz, flint, sand and gravel pebbles may be selected. The children having determined their relative densities, the agreement between the results may be pointed out and the identity of the material explained. By drawing perpendiculars corresponding in height to the densities of various substances, a graphic representation is obtained which serves to bring out the value of the graphic method of representation.

A very valuable exercise to introduce at this stage is based on the well-known fact that in certain conditions of the atmosphere things appear moist: a muslin bag full of seaweed may be hung up under cover but freely exposed, and may then be weighed daily at a given time; simultaneously the state of the weather, direction of the wind, the height of the barometer, and the state of the wet and dry bulb thermometer may be noted; on tabulating the results, and especially if the graphic method be employed, the variations and their relationship will be noticeable.

The thermometer, having thus become a familiar instrument, may be used to examine melting ice and boiling water; the construction of both the Centigrade and Fahrenheit thermometers may then be explained, and the effect of heat on bodies made clear. The density of ice and of water at various temperatures may then be determined, a Sprengel tube—which is easily made—being used for warm water; the bursting of pipes in winter, the formation of ice on the surface of water, &c., may then be explained. Afterwards simple determinations of the heat capacity of a few metals, &c., and of the latent heat of water and steam, may be made in accordance with the directions given in a book such as Worthington's 'Practical Physics.'

STAGE III.—*Studies of the effect of heat on things in general; of their behaviour when burnt.*

As it is a matter of common observation that heat alters most things, the effects of heat on things in general should be studied; in the first instance qualitatively, but subsequently, and as early as possible, quantitatively. Bits of the common metals may be heated in the bowl of an ordinary clay pipe plunged into a clear place in any ordinary fire, or in such a pipe or a small iron spoon over a gas flame. The difference in fusibility is at once apparent, and in the case of metals like iron and copper it is noticeable that although fusion does not take place, a super-

ficial change is produced; the gradual formation of a skin on the surface of fused lead and tin is also easily perceived. Observations like this become of great importance at a later stage, and indeed serve to suggest further experiments: this is a point of special importance, and from the beginning of this stage great attention should be paid to inculcating habits of correct observation; the effect should first be recorded by the pupil, the notes should then be discussed and their incompleteness pointed out, and they should afterwards be re-written. The fusibility of substances which are not affected when heated in the tobacco pipe may be tested by heating them with a Fletcher gas blowpipe on charcoal; and by heating little bits of wire or foil in such a flame it is easy for children to discover the changes which metals undergo when burnt, especially in cases such as that of zinc or copper or iron.

The further study of the effect of heat should be quantitative, and may well commence with water. It being observed that water disappears on heating, water may be put into a clock glass or glass dish placed on a water bath (small saucepan); it evaporates and it is then observed that something is left. A known quantity of water by weight or volume is therefore evaporated and the residue weighed. This leads to the discovery that water contains something in solution. The question then naturally arises, What about the water that escapes? so the steam is condensed and the distilled water evaporated. The conception of pure water is thus acquired. An experiment or two on dissolution—using salt and sugar—may then be introduced, a water oven or even an air oven (a small Fletcher oven) kept at a known temperature being used, and the residue dried until the weight is constant. Rain- and sea-water may next be examined; the results afford an opportunity of explaining the origin of rain and of accounting for the presence of such a large quantity of dissolved matter in sea-water. Then the various common food materials may be systematically studied, commencing with milk; they should first be dried in the oven, then carbonised and the amount of char determined, then burnt and the percentage of ashes determined. A small platinum dish, 15 to 20 grams in weight, is required for these experiments, and a gas muffle furnace is of the greatest use in burning the char and in oxidising metals. In addition to the discipline afforded by such experiments a large amount of valuable information is acquired, and the all-important fact is established that food materials generally are combustible substances. Afterwards mineral substances are examined in a similar manner, such as sand, clay, chalk, sulphur, &c., and then metals such as lead, copper, tin and iron may be studied; their increase in weight is in striking contrast to the inalterability of substances like sand and salt, and the destruction of vegetable and animal substances. Chalk, from which lime is made by burning, is found to occupy a middle position, losing somewhat in weight when strongly heated. The exceptional behaviour of coal among mineral substances, and of salt among food materials is shown to be capable of explanation inasmuch as coal is in reality a vegetable and salt a mineral substance; but sulphur remains an instance of exceptional behaviour requiring explanation. It is not exceptional in being combustible as metals like magnesium and zinc are combustible, but in affording no visible product. The smell of burning sulphur, however, serves to suggest that perhaps after all there is a something formed which is an invisible substance possessed of an odour, and then follows quite naturally the suggestion that perhaps in other cases where no visible or perceptible product is obtained—as on burning

charcoal, for instance—there may nevertheless be a product. Whereas, therefore, in Stage I. the pupil will have learnt to appreciate the existence of a great variety of substances, and will have gained the power of describing their outward appearance more or less fully; and in Stage II., having learnt how to measure and weigh, will acquire the habit of determining by measurement certain properties of substances, and will thus be in a position to express in exact terms the kind of differences observed; in Stage III. the pupil will be led to see that profound changes take place on burning substances, and that these changes involve something more than the destruction of the things burnt. The foundation is thus laid for the study of change, *i.e.*, chemical studies proper.

Stage IV.—*The problem stage.*

Many of the changes observed in the course of the experiments made in Stage III. might be examined and their nature determined, but the best to take first is a very familiar case, that of the rusting of iron.

Problem I. *To determine what happens when iron rusts.*—The pupil *must* be led in the first instance to realise that a problem is to be solved and that the detective's method must be adopted and a *clue* sought for. It is a familiar observation that iron rusts, especially when wet; what happens to the iron, why does it rust, is the iron alone concerned in the change? No information can be gained by looking at it—perhaps the balance which has brought to light so much in Stage III. may be of service, so the iron is allowed to rust in such a manner that any change in weight can be observed. A few grams of iron-filings or borings are put on to a weighed saucer or clock glass along with a bit of stiff brass or copper wire to be used as a stirrer; the iron is weighed, then moistened and exposed under a paper cover to keep off dust, preferably in a warm place; it is kept moist and occasionally stirred. After a few days it is dried in the oven and then weighed. The weight is greater. *Something from somewhere has been added to the iron.* Thus the clue is gained. Where did this something come from? The fact that when a tumbler, for instance, is plunged mouth downwards into water the water does not enter, and that on gradually tilting the tumbler to one side something escapes—viz., air—at once affords a demonstration of the presence of air in the space around us. The iron rusted in this air, but was kept moist, so it may have taken up the something from either the air or the water. To ascertain whether the air takes part in the rusting, some iron borings are tied up in a bit of muslin and the bag is hung from a wire stand placed in a (jam) pot full of water and a so-called empty (pickle) bottle, which in reality is full of air, is inverted over the iron; in the course of a few hours, as the iron rusts, the water is observed to rise until it occupies about one-fifth of the jar (determined by measuring or weighing the water); the something added to the iron during rusting appears therefore to come from the air, and the all-important fact is thus discovered that the rusting is a change in which not the iron alone, but also the air, is concerned. The experiment is several times repeated, fresh iron being used with the same air and the same iron put in succession into fresh portions of air, but the same result is always obtained: whence it follows that whatever it is in the air which takes part in the rusting, the air as a whole is not active. The changes previously ob-

served to take place when iron, copper, lead, zinc, &c., were heated in air, are then recalled; as the metals were found to increase in weight it would appear probable that in these cases of change also the air was concerned.

These results at once suggest the question, What is air? So much having been learnt by studying the change which iron undergoes in rusting, other changes which happen in air therefore are next studied.

PROBLEM II. *To determine the nature of the changes which take place on burning substances in air.*—The use of phosphorus is introduced by reference to a match. Phosphorus is then burnt under a bell jar over water and the result noted: the disappearance of some of the air again shows that the air is concerned. The fact that phosphorus smokes when taken out of the water in which it is always kept suggests that some change is going on, so a stick of phosphorus is exposed in air as in the previous experiment with iron: soon one-fifth has disappeared and the phosphorus then ceases to smoke. The *quantitative* similarity of the two results suggests that iron and phosphorus behave alike towards air and *vice versâ*, and serves to confirm the idea that some constituent of the air present only to the extent of about one-fifth is active. But nothing is to be taken for granted, so iron is exposed in the phosphorus-air residue and phosphorus in the iron-air residue: as no change occurs there is no room left for doubt. Recalling the experiments in which various metals were burnt in air in order to determine whether in these cases the same constituent of the air was concerned in the change, air from which the active constituent has been removed by means of iron is passed through a heated tube containing bits of the metals: no change is observed, so it is evident that as a rule, if not always, one and the same constituent of air is concerned. The experiments with iron and phosphorus, although they show that the air is concerned in the changes which are observed to take place, do not afford any information whether or no the water which is also present is concerned in the change. Phosphorus is therefore burnt in a 'Florence' flask closed with a rubber stopper: on removing the stopper under water some water enters, and by measuring this and the amount of water which will fill the flask the same result is obtained as in the previous cases. To be certain whether in this case anything enters or escapes from the flask it is weighed before and after the phosphorus is burnt. There is no change in weight. But does nothing escape? Yes, much heat; whence it follows that heat is not material: that, although some of the air disappears, it is merely because it has become affixed to or absorbed by something else. This has been proved in the case of the rusting iron and the burnt metals. To obtain indisputable evidence in the case of the phosphorus this is burnt in a current of air in a tube loosely filled with asbestos to retain the smoke: the weight is found to increase. The observation that the phosphorus ceases to burn after a time suggests the introduction of a burning taper into the residue left by iron, &c.; it is found to be extinguished. Then a candle and subsequently a gas flame may be burnt in a bell jar full of air over water. Reversed combustion may then be demonstrated in order to fully illustrate the reciprocal character of the phenomena. Thus it is ascertained that all ordinary cases of combustion are changes in which the air, and not the air as a whole but a particular constituent, is concerned, and no doubt remains that the same constituent is always active, but active under different conditions; it is

realised also that the production of heat is the consequence of the union of the substance burnt with the active substance in air. The experiment of exposing phosphorus in air affords the opportunity of demonstrating the evolution of heat even in a case where no visible combustion occurs, as the phosphorus is always observed to melt. At this stage careful note should be taken of the appearance of the different products of combustion and of a change such as that which occurs when the product from phosphorus is exposed to the air.

PROBLEM III. *To separate the active from the inactive constituent of air.*—It now has become of importance to get this active constituent of the air by itself, and the question arises whether it cannot be separated from one of the metals or other substances with which it has been found to combine. The pupil is therefore told to collect information about the different substances formed by burning metals, &c.—whether they can be obtained in sufficient quantity to work with, &c. Iron rust and iron scale are easily obtainable, and so is copper scale; zinc is burnt to produce zinc white which is used as paint; lead is also burnt on a large scale, and in this case it appears that one or other of two substances is formed—litharge at a high temperature, red lead at a lower temperature. This peculiarity of lead suggests the study of the two products in the hope of discovering the clue to a method. Weighed quantities of the litharge and red lead are heated; it is observed that only the latter changes in appearance and that it loses weight. But what does it lose? It was formed by merely roasting lead in the air and the something which it loses must therefore have been derived from the air. If the red lead is heated in a tube a gas is given off which is collected and tested—how? with a taper or glowing splinter as it is to be supposed that the gas will support combustion if, as is to be expected, it is the active constituent of air. The *discovery* of the active constituent of air is thus made! If air consist of this gas and that which remains after exposing phosphorus or iron in air, then by adding to such residual air as much of the gas from red lead as was withdrawn, air should be re-obtained; this is found to be the case. The names of the two gases are now *for the first time* stated, and an easy method of preparing oxygen is demonstrated, such as that of heating a chlorate, but without any explanation. The conclusion previously arrived at, that probably in all the cases previously studied of changes occurring in air the oxygen is the active substance, may now be verified by burning or heating in oxygen the substances which had been burnt in air. The comparison of the densities of the two gases with that of air should then be made.

So much having been learnt of the chemistry of air, the study of the pressure exercised by air may next be taken up, and the common pump, the force pump, the barometer and air currents may be discussed and explained. Nowadays the charts given in the daily papers, and the Ben Nevis and Glycerin barometer readings quoted in the 'Times' make it particularly easy to explain the barometer. The pupils should be led to make barometer curves.

PROBLEM IV. *To determine what happens when chalk is burnt to lime.*—The discovery of the *composition* of the air in the course of experiments made with the object of determining the nature of certain changes naturally suggests that the attempt should be made to ascertain the composition of other things by studying the changes which they undergo. Chalk is known to give lime when burnt, and experiments made in Stage III.

have indicated that chalk loses something when burnt—the idea that an invisible something is given off is especially probable after the experiments with red lead have been made; so it is decided to heat chalk strongly, but before doing this chalk and lime are examined comparatively. Chalk is observed not to be altered by water; on shaking it with distilled water and evaporating some of the filtered liquid in a weighed dish, very little residue is obtained—so it is established that it is but very slightly soluble in water. Lime is slaked, weighed quantities of lime and water being used; the retention of a considerable amount of water, even after exposing the slaked lime in the drying oven, shows that the slaking involves a definite change in composition—that slaked lime is lime and water. The solubility of the lime is next determined and found to be considerably greater than that of the chalk. It is found that chalk is but very slightly altered in weight when heated over a gas flame, and that it is only when it is strongly heated that it is converted into lime: so the chalk is strongly heated in an iron tube in a Fletcher blowpipe furnace, when gas is freely given off, and subsequently it is found that the chalk has become lime. The gas is tested with a taper, which it extinguishes, so it cannot be oxygen, but may be nitrogen; its density is therefore compared with that of nitrogen and found to be greater, so evidently it is a peculiar gas and may be called chalk gas. If chalk consist of this gas and lime, it should be possible to reproduce chalk from them; so the gas is passed through a small weighed tube containing lime and the tube is found to get heavier. But lime and chalk are so much alike that it is difficult to say that chalk is formed: perhaps dissolved lime will act similarly; the gas is therefore passed into or shaken up with lime water. The precipitate which forms looks like chalk and probably is, but this remains to be decided. The discovery of this behaviour of chalk gas is important as affording a means of again comparing the gas from chalk with nitrogen. In working with lime water it is scarcely possible to avoid noticing that a film forms on its surface; by exposing a quantity of the lime water a considerable amount of the precipitate is obtained: its resemblance to chalk is noted, and the possible presence of chalk gas in air is thereby suggested; this and the precipitates previously obtained are collected, dried, and then introduced into pieces of narrow hard glass tubing, connected to wash-bottles containing lime water, and on heating strongly by means of a blow-pipe flame, while air is sucked through to carry forward any gas into the lime water, the white precipitates are again obtained, so no doubt remains that the original precipitates were chalk. Incidentally the discovery is thus made that air contains something besides oxygen and nitrogen, viz., chalk gas.

It being thus established that chalk consists of two things, lime and chalk gas, at this stage it is pointed out how firmly these two constituents hold to each other in the chalk. The absorption of the gas by the lime—its entire disappearance in fact—is commented on. Accurate determinations of the loss of weight on heating crystallised chalk (calc spar) should at this stage be carried out before the class, if not by the pupils, so that the numbers may be quoted and that it may become impressed on them that the proportions in which the lime and chalk gas are present is constant. Their attention may be recalled to the oxides previously studied, it being pointed out that on inspection these afford no indication that they contain oxygen: that here again the gas entirely loses its individuality on entering into union or combination. That oxides contain their constituents in fixed proportions may be de-

monstrated experimentally by oxidising finely-divided copper and determining the increase in weight, lime being used as drying agent. In this way the characteristics of *compounds* are elucidated. Then the comparison may be made with air and the fact made clear that it behaves as a mere mixture. Still no reference should be made to elements.

PROBLEM V. *To determine what happens when organic substances are burnt.*—The experiments thus far made have shown that phosphorus and a number of metals burn in the air because they combine with the oxygen, forming oxides, heat being given out *as a consequence*; but that chalk when burnt is split up or decomposed into lime and chalk gas, this result being a consequence of the heating alone, the air having nothing to do with it. It remains to ascertain what happens when organic substances are burnt, as these give no visible product beyond a little ashes. As in all cases when vegetable or animal substances are burnt a certain amount of 'char' is obtained, which then gradually burns away, charcoal or coke is first studied. It having been discovered that the oxygen in air is the active cause of burning in many cases, it appears probable that the air is concerned in the burning of charcoal, coal, &c. As when once set fire to these continue to burn, the charcoal is at once heated in oxygen: it burns, but no visible product is formed; it therefore follows that if the charcoal is oxidised the oxide must be an invisible gas. How is this to be tested for? What gases are already known to the pupil? How are these distinguished? Oxygen is excluded. Is it perhaps nitrogen, and is not perhaps the nitrogen in air merely used-up oxygen as it were, produced by the burning of organic substances? Or is it perhaps that gas which was found in the air along with oxygen and nitrogen, and which turned lime water turbid? This last being an easy test to apply is at once tried; the lime water is rendered turbid, and so as to leave no doubt a sufficient amount of the gas is prepared and passed into lime water, and the precipitate is collected: it is found to give off chalk gas when heated, and when the loss it suffers on heating is determined it is found to agree with that suffered by the precipitate prepared from chalk gas. Thus the discovery is made that chalk gas is an oxide of carbon, and that chalk consists of at least three things.

It may be objected that to make the experiment in this manner takes too much time; but to this it may be answered that such experiments are precisely similar to those made in actual practice, and that they exercise a most important influence in teaching the pupils to take nothing for granted, never to jump at conclusions, and to rest satisfied if they progress surely, however slow the advance may be.

The char from a number of organic substances may now be burnt in oxygen, and the gas passed into lime water; chalk gas is found in every case to be a product, and hence the presence of a common constituent—carbon—in all is established. In burning substances such as sugar, it is scarcely possible to avoid noticing the formation of a liquid product, so it is evident that chalk gas is not the only product of their combustion, or carbon their only constituent.

Food materials generally having been found to contain 'carbon,' as they are obviously in some way destroyed within the body, and it is known that air is necessary for life, the question arises, what becomes of food, and why is air necessary for life? Is the food, perhaps, in large part 'burnt up' within the body, thus accounting for the fact that our bodies are always warm? The characteristic product of combustion of

carbonaceous substances is therefore tested for by breathing into lime water. The discovery thus made affords an opportunity for a digression and for explaining how plants derive their carbon from the air.

PROBLEM VI. *To determine what happens when sulphur is burnt.*—From the results of the experiments with carbon, it appears probable that the disappearance of sulphur when burnt is also really due to its conversion into a gaseous oxide, so it is kindled and introduced into oxygen: if it be burnt over water in a bell jar in a spoon passing through the stopper (a rubber cork), the water is seen to rise; if, on the other hand, it be burnt in a dry flask closed by a rubber cork carrying a gauge-tube, as suggested by Hofmann,[1] the volume is seen to be almost unchanged after combustion. It follows, therefore, that the sulphur and oxygen unite and form a soluble product. Sulphur is next burnt in a tube in a current of oxygen, and the gas is passed into water; a solution is thus obtained having the odour of the gas and sour (acid) to the taste. The fact that carbon and sulphur—both non-metals—behave alike in yielding gaseous oxides suggests that a comparison be made of their oxides: so the acid solution is added to lime water; a precipitate is formed, which redissolves on adding more of the sulphur gas solution; on the other hand, on adding the lime water to the acid liquid, this latter after a time loses its characteristic smell. There can be no doubt, therefore, that the sulphur gas does in some way act upon the lime. The discovery that the addition of more of the sulphur oxide leads to the dissolution of the precipitate which it first forms in lime water suggests trying the effect of excess of the carbon oxide on the lime water precipitate; this is done, and the discovery is made that the precipitate gradually dissolves. The solubility of the new substance may then be determined by passing the gas into water containing chalk in suspension, filtering, and evaporating. This leads to the observation that a precipitate is formed on heating the liquid, and this is soon found to be chalk. An opportunity is thus afforded of explaining the presence of so much 'chalk' in water; of demonstrating its removal by boiling and by lime water; and the effect it has on soap.

The observation that the oxides of both carbon and sulphur combine with lime suggests trying whether the one will turn out the other, so the solution of the sulphur oxide is poured on to chalk: effervescence is observed, and on passing the gas into lime water a precipitate is obtained. The production of this effect by the *acid* solution suggests trying common vinegar—a well-known *acid* substance. This also is found to liberate chalk gas, and the discovery of an easy method of preparing chalk gas is thus made. The oxide formed on burning phosphorus, having previously been found to give an acid solution, is tried, and it is found that it also liberates chalk gas. As a good deal of vinegar is found to give very little chalk gas, the question arises, Are there not acids to be bought which will have the same effect and are stronger and cheaper? On inquiry it is found that sulphuric acid or oil of vitriol, muriatic acid or spirits of salts, and nitric acid or aquafortis may be bought, and that these all act on chalk. The behaviour of chalk with acids affords a means of testing the lime water precipitate obtained in working out Problems IV. and V. In this manner the pupil is led to realise that certain agents may

[1] By burning carbon also in this way a most effective demonstration is given of the fact that no loss or gain of matter attends the change, and that only heat escapes; the results in the case of carbon and sulphur are particularly striking, as the products are gaseous and invisible.

very readily produce effects which are only with difficulty produced by heating—that the *chemical agent* may produce very powerful effects. The ready expulsion of the carbon oxide of the chalk suggests that other substances not yet studied, such as the metals, when treated with acids may behave in a special manner which will afford information as to their nature. At this point, prior to making the experiments with the acids, an explanation may be given of the names *oil of vitriol*, *spirits of salts* and *aquafortis*; the processes by which they are made may be described and illustrated, without, however, any attempt being made to explain them from the chemical point of view. The sulphuric acid should be made from green vitriol, and its behaviour on dilution should be demonstrated as well as its use as a drying agent.

PROBLEM VII. *To determine what happens when metals are dissolved in acids.*—Iron, zinc, lead, tin, copper and silver may be taken. On pouring diluted oil of vitriol on to iron or zinc, the metal dissolves with effervescence; the gas is collected, and when tested is found to burn. Thus a new gas is discovered, differing from all which have previously been studied, inasmuch as it is combustible; in order not to interrupt the study of the action of acids on metals, however, its further examination is postponed for a while. Resuming the experiments with metals, lead, tin, copper and silver are found not to be acted upon by diluted oil of vitriol.

Muriatic acid, in like manner, dissolves iron and zinc and also tin with effervescence, and the gas which is given off in each case exhibits the same behaviour as that obtained from iron or zinc and diluted oil of vitriol. Lead, copper and silver are not appreciably affected.

Aquafortis is found to dissolve not only iron and zinc but also copper, lead and silver, and to convert tin into a white substance—to attack all the metals in fact, thus justifying its name. The gas which is given off as the metal dissolves is observed to be coloured; when it is collected over water, however, it is seen to be colourless, and to become coloured on coming into contact with air—oxygen and nitrogen are, therefore, added to portions of the gas over water. In this manner, not only is a new gas discovered, but also a test for oxygen; and opportunity is afforded of here calling attention to the fact that air behaves exactly as oxygen, that the oxygen in air appears to be unaffected by its association with nitrogen—that, in fact, it is uncombined. From these experiments it is obvious that metals and acids interact in a variety of ways. Finally, the dissolution of gold and platinum by aqua regia may be demonstrated.

PROBLEM VIII. *To determine what happens when oxides are acted on by acids.*—In the course of the previous experiments a number of oxides have been prepared by burning various metals in air; these are found to be unchanged by water. The discovery that acids act on metals suggests a trial of the effect which acids will have on their oxides; so the oxides of zinc, iron, copper and lead are submitted to the action of the three acids previously used. Sulphuric acid is found to dissolve zinc oxide, iron rust and copper oxide, but no gas is evolved; excess of the oxide may be used, and the filtered liquid concentrated; the crystals which separate may be examined and compared with those obtained by dissolving the metal in sulphuric acid, &c. Litharge apparently is not changed by sulphuric acid, but red lead is, although not dissolved. Muriatic acid being used, all the oxides are found to dissolve, and in the case of red lead a greenish yellow gas is given off possessing a most

disagreeable smell; this is noted as a case for study. The product from the lead oxides is observed to crystallise out from the hot liquid on standing, so the undissolved original product is boiled up with water, and the solution is filtered, &c. Attention is thus directed to the difference in solubility of the products. Next, aquafortis is used; again all are dissolved, except the red lead, which, however, is obviously altered. In the case of the lead oxides the product is again less soluble than those afforded by the other oxides, but more soluble than the product obtained on using muriatic acid. The pupil has already been led to realise that of two substances capable of acting on a third, such as chalk gas and sulphur gas, which both combine with lime, one may be the stronger, and may turn out the other, sulphur gas turning out chalk gas from chalk. A comparison of the three acids with the object of ascertaining which is the strongest is therefore suggested—the metal or oxide is dissolved in one of the acids, and the others are then added. No positive result is obtained in the case of zinc, iron or copper, but the solution of lead in nitric acid is precipitated by muriatic and by sulphuric acid; the former precipitate is found to dissolve in boiling water and to crystallise out in exactly the same way as the substance obtained from lead oxide and muriatic acid. The sulphuric acid product is found to be almost insoluble in water, and also in muriatic and nitric acids; these observations make it possible, by examining the behaviour towards muriatic and nitric acids of the products of the action of sulphuric acid on the lead oxides, to establish the fact that the product is the same whether lead be dissolved in nitric acid and sulphuric acid be then added, or whether either of the oxides be treated with sulphuric acid. It is further evident that those acids which give difficultly soluble or insoluble products act with difficulty if at all on the metal. Other metals besides those mentioned may be now studied, and, a solvent being found, the acids which do not dissolve the metal may be added to the solution. In this way, for example, the chloride test for silver is discovered.

In experimenting with acids the pupils can hardly fail to stain their clothes and their fingers. The observation that acids alter colours serves to suggest experiments on the action of acids on colours, especially those of leaves and flowers. The use of litmus, methylorange, cochineal, &c., may then be explained. As various oxides have been found to 'neutralise' acids, the study of their effect on the colours altered by acids is suggested. Lastly, a few experiments with vegetable and animal substances, sugar, &c., may be made, which demonstrate the corrosive action of oil of vitriol and aquafortis.

PROBLEM IX. *To determine what happens when the gas obtained by dissolving iron or zinc in sulphuric or muriatic acid is burnt.*—The gas has been observed to burn with a smokeless, odourless flame. To ascertain whether, as in all other cases of combustion previously studied, the oxygen of the air is concerned in the combustion, a burning jet of the gas is plunged into a dry cylinder full of oxygen, in which it is not only seen to continue burning, but it is also noticed that drops of liquid condense on the cylinder above the flame; this immediately suggests that the product is a liquid. The jet is found to be extinguished in nitrogen, so evidently when the gas burns it forms an oxide. The experiment is repeated, and the gas burnt in a bell jar full of oxygen over water: the water rises as the combustion proceeds, proving that the oxygen is used up. To collect a sufficient quantity of the product for examination,

the dried[1] gas is burnt at a jet underneath a Florence flask through which a stream of cold water is allowed to circulate: the neck of the flask is passed through the neck of a bell jar and the flask and bell jar are clamped up in an inclined position, so that the liquid which condenses may drop into a small beaker placed below the rim of the jar. What is the liquid? It looks very like water, and is without taste or smell. Is it water? How is this to be ascertained? What are the properties of water? The knowledge previously gained here becomes of importance. It has been observed that frozen water melts at 0° Centigrade, that water boils at 100°, and that one cubic centimetre weighs one gramme at 4° C.; so the liquid is frozen by the ice-maker's mixture of ice and salt, a thermometer being plunged into it so that the solid ice forms on the bulb: the melting-point is then observed. Subsequently the boiling-point is determined, a little cotton-wool being wrapped around the bulb of the thermometer. Lastly, the density of the liquid may be determined. It is thus established that the gas yields water when burnt, and the name of the gas may now *for the first time* be mentioned and explained. The results thus obtained leave little doubt that water is an oxide of hydrogen; but in order to place this beyond doubt it is necessary to exclude nitrogen altogether. How is this to be done? Red lead is known to consist of lead and hydrogen only, and readily parts with a portion at least of its oxygen; so dried hydrogen is passed over red lead, which is then gently heated. Again a liquid is obtained which behaves as water, so there can be no doubt that water is an oxide of hydrogen. Water is not obtained on merely mixing oxygen and hydrogen; it is only produced when combustion takes place. To start the combustion a flame is applied to a small quantity of a mixture of the two gases: a violent explosion takes place. An opportunity is here again afforded of calling attention to the entire change in properties which takes place when the compound is formed. On heating red lead in hydrogen, lead is obtained, although on heating it alone it loses only a portion of its oxygen, and the 'reduction' takes place very readily; evidently, therefore, hydrogen is a powerful agent. This observation suggests further experiments. Will it not be possible to remove oxygen by means of hydrogen from other oxides which are not altered on heating? and will not other combustible substances besides hydrogen remove oxygen from oxides?

PROBLEM X. *To determine what happens when hydrogen and other combustible substances are heated with oxides.*—Zinc oxide, iron rust and copper oxide are now heated in a current of hydrogen: the first remains unaltered, the other two are seen to change, a liquid being formed which it cannot be doubted is water; the copper oxide evidently becomes reduced to copper. Is the iron rust similarly reduced to the metallic state? How is iron to be tested for? Iron is attracted by the magnet, and dissolves in diluted oil of vitriol with evolution of hydrogen. Applying these tests, no doubt remains that the iron rust is deprived of its oxygen.

Litharge and copper oxide may then be mixed with soot or finely powdered charcoal and heated in tubes; gas is given off which renders lime water turbid, and metallic lead or copper is obviously obtained. It is thus established that some but not all oxides may be deprived of

[1] The importance of drying the gas is realised without difficulty, as previous observations have shown that the air is moist, and as the gas is given off in presence of water; lime may be used.

their oxygen by means either of hydrogen or carbon. Opportunity is here afforded of explaining the manufacture of iron.

Several dried combustible organic substances, sugar, bread and meat, may now be burnt with copper oxide in a tube the fore part of which is clean and is kept cool: liquid is seen to condense, while 'chalk gas' is given off; the liquid has the appearance of water, and sufficient may easily be obtained to ascertain whether it is water. The presence of hydrogen in organic substances is thus discovered; its origin from water may now be explained, and the double function of water in the plant and animal economy may be referred to—viz., that it both enters into the composition of the animal and plant structure and also acts as a solvent. The combustion of ordinary coal gas, of alcohol, of petroleum, of oil and of candles, may then be studied, and the presence of hydrogen in all of these noted.

Problem XI. *To determine whether oxides such as water and chalk gas may be deprived of oxygen by means of metals.*—It being found that hydrogen and carbon withdraw the oxygen from some but not from all metallic oxides, it follows that some metals have a stronger, others a weaker, hold upon or 'affinity' to oxygen than has either hydrogen or carbon; the question arises whether any and which metals have so much greater an affinity to oxygen that they will withdraw it from hydrogen and carbon. Copper and iron have been found to part with oxygen, but zinc and magnesium did not, so these four metals may be studied comparatively. Steam is passed through a red-hot copper tube full of copper tacks: no change is observed. The experiment is repeated with an iron tube charged with bright iron nails: a gas is obtained which is soon recognised to be hydrogen, and on emptying out the nails they are found to be coated with black scale. Zinc and then magnesium are tried, and, like iron, are found to liberate hydrogen. Chalk gas is next passed over red-hot copper, and is found to remain unchanged, but on passing it over red-hot iron or zinc a gas is obtained which burns with a clear blue smokeless flame: this gas is not absorbed by milk of lime, but on combustion yields chalk gas, so it evidently contains carbon, and is a new combustible gas. Like hydrogen, it is found to afford an explosive mixture with oxygen. Finally, magnesium is heated in chalk gas: it is observed to burn, and the magnesium to become converted into a blackish substance unlike the white oxide formed on burning it in air. But it is to be expected that this oxide is produced, and to remove it, as it is known from previous experiments to be soluble in muriatic acid, this acid is added: a black residue is obtained. What is this? Is it not probable that it is carbon? If so, it will burn in oxygen yielding chalk gas. So the experiment is made. These experiments in which hydrogen is obtained from water, and carbon from chalk gas, afford the most complete 'analytic' proof of the correctness of the conclusions previously arrived at regarding water and chalk gas, and which were based on 'synthetic' evidence; taken together, they illustrate very clearly the two methods by which chemists determine composition.

As hydrogen and carbon form oxides from which oxygen may be removed by means of some metals but not by all, the question arises, which has the greater hold upon or affinity to oxygen—carbon or hydrogen? As it is the easiest experiment to perform, steam is passed over red-hot charcoal: a combustible gas is obtained which yields water and chalk gas when burnt, so evidently the hydrogen is deprived of its

oxygen, and this latter combines with the carbon, forming the combustible oxide of carbon. Will not carbon partly deprive chalk gas of its oxygen? The experiment is made and it is found that it will. These results afford an opportunity of calling attention to and explaining the changes which go on in ordinary fires and in a furnace.

PROBLEM XII. *To determine the composition of salt gas, and the manner in which it acts on metals and oxides.*—It has previously been demonstrated that spirits of salt or muriatic acid is prepared by acting on salt with oil of vitriol and passing the gas which is given off into water; the solution has been found capable of dissolving various metals and oxides, chalk, lime, &c., and as water alone does not dissolve these substances the effect is apparently attributable to the dissolved gas, so it becomes of interest to learn more of this gas in order that its action may be understood. It is first prepared; its extreme solubility in water is observed, and also the fact that as it dissolves much heat is given out; and it is noted that although colourless and transparent it fumes in the air. How is its composition to be determined? Is there any clue which can be followed up? Reference is made to the previous observations, and it is noted that its solution dissolves various metals with evolution of hydrogen; water alone has no such effect. Is this hydrogen derived from the water or from the dissolved gas? The gas alone is passed over heated iron turnings, and the escaping gas is collected over water: it proves to be hydrogen, so evidently salt gas is a compound of hydrogen with something else. How is this something else to be separated from the hydrogen? Do not previous experiments suggest a method? Yes, they have proved that hydrogen has a marked affinity to oxygen, and now it is recollected that on treating muriatic acid with red lead—a substance rich in oxygen—a greenish-yellow gas is obtained. The experiment is repeated on a larger scale and the gas is examined. If it is contained together with hydrogen in salt gas, perhaps salt gas will be obtained on applying a flame to a mixture of the two gases just as water is from a mixture of oxygen and hydrogen: the mixture is made and fired, and the result leaves little doubt that salt gas does consist of hydrogen in combination with the greenish-yellow gas —chlorine. Whence is this chlorine derived—from the salt or the sulphuric acid?

The notes are again consulted, and it is seen that a solution of silver in nitric acid gave a characteristic precipitate with muriatic acid but not with sulphuric, so salt solution is added to the silver solution, and a precisely similar precipitate is obtained, leaving little doubt that the chlorine is derived from the salt. It is now easily realised that the iron and zinc displace the hydrogen of the dissolved hydrogen chloride. What happens when the oxides are acted on? In addition to the metal they contain oxygen, which is known to combine readily with hydrogen, forming water; is water formed? Zinc oxide is therefore heated in hydrogen chloride; a liquid is obtained which behaves exactly as a solution of hydrogen chloride in water. When the action is complete, and all that is volatile has been driven off by heat, a solid remains very like fused common salt—doubtless zinc chloride, since it is to be supposed that as the hydrogen has taken the place of the zinc the chlorine has taken the place of the oxygen. What, then, is the action of hydrogen chloride on chalk? It evidently not only separates the chalk gas from the lime, but also dissolves this latter. What is formed? Dry (unslaked) lime is therefore heated in a current of hydrogen chloride. It behaves just as zinc oxide,

yielding a liquid product—evidently a solution of hydrogen chloride in water, as it dissolves zinc with evolution of hydrogen, and the residue is like that of zinc chloride. The important discovery is thus made that lime also is an oxide—that chalk, in fact, is a compound of two oxides; the resemblance of lime to zinc oxide and magnesium oxide is so striking that the conclusion is almost self-evident that lime is probably a metallic oxide, and it may be here pointed out that this actually is the case. The gradual discovery of the composition of chalk in the manner indicated is an especially valuable illustration of chemical method, and serves to show how chemists are often obliged to pause in their discoveries and to await the discovery of new facts and methods of attack before they are able to completely solve many of the problems which are submitted to them. The solids obtained on dissolving zinc oxide and lime in muriatic acid and boiling down the solution, when all the water is driven off, are white solids like fused salt, but on exposure they gradually become liquid. In so doing they increase in weight, and evidently behave like sulphuric acid. Probably water is absorbed from the air: no change takes place when they are kept over sulphuric acid or dry lime. In this way two new desiccating agents are incidentally discovered.

Problem XIII. *To determine the composition of washing soda.*—The study of this substance is of importance as introducing the conception of an alkali. The preparation of washing soda from salt is first described. On heating the crystals they melt and give off 'steam'; the experiment is made in such a way that a quantity of the liquid is obtained sufficient to place beyond doubt that it is water. The water is found to be easily driven off on heating the crystals in the oven, and to constitute a very large proportion of the weight of the crystals. The conception of water of crystallisation is thus gained. On heating the dried substance to full redness in the platinum dish, no loss occurs. The residue dissolves in water, and 'soda crystals' may again be obtained from the solution, so that heat does not affect it. Perhaps acids which have been found to act so powerfully in other cases will afford some clue—on trial this is found to be the case: a colourless, odourless gas is given off, which extinguishes a burning taper. Is this perhaps nitrogen or chalk gas? The lime-water test at once decides that it is the latter. So it is determined that washing soda, like chalk, is a compound of chalk gas—but with what? With an oxide? The dried substance is heated in hydrogen chloride: chalk gas is given off as before, and a liquid which is soon recognised as water saturated with hydrogen chloride. The residue dissolves in water, and separates from the concentrated solution in crystals exactly like salt, and, in fact, is soon recognised to be salt; evidently, therefore, that which is present in salt along with chlorine is present in soda crystals along with oxygen, chalk gas and water. The preparation of the metal sodium from soda is then explained. Acquaintance being thus made with compounds of chalk gas with two different oxides, the question arises, which oxide has the greater affinity to the chalk gas? Will lime displace sodium oxide from soda or *vice versâ*? On adding lime water to soda solution, a precipitate of chalk is formed. What does the solution contain? Lime water contains lime in combination with water; is the sodium oxide present in combination with water? Soda is boiled with milk of lime (in an iron saucepan to avoid breakage) until it no longer affects lime water; afterwards the liquid is poured off and boiled down. The product is very unlike soda: it is very caustic, and when

exposed to the air becomes liquid. If it is an analogous substance to slaked lime, it should combine with chalk gas and be reconverted into soda; this is found to be the case. Caustic soda is thus discovered. Chalk and lime are known to neutralise acids; both soda and caustic soda are found to do so, and their effect on vegetable colours is found to be the reverse of that of acids. At this stage the origin of the name alkali is explained, and it is pointed out that the oxides which have been studied may be arranged in two groups of alkali-like or *alkylic* and acid-forming or *acidic* oxides, the former being derived from metals, the latter from non-metals. The production of *salts* by the union of an oxide of the one class with the oxide of the other class is then illustrated by reference to earlier experiments.

The point is now reached at which the results thus far obtained may be reconsidered. The student has been led in many cases to make discoveries precisely in the manner in which they were originally made; and it is desirable that at this stage, if not earlier, the history of the discovery of the composition of air and water, &c., should be briefly recited. It is then pointed out that a variety of substances have been analysed and resolved into simpler substances—air into oxygen and nitrogen, water into oxygen and hydrogen, &c.; and that these simpler substances thus far have resisted all attempts to further simplify them, and are hence regarded as elements. A list of the known elements having been given, the diverse properties of the elements may be illustrated from the knowledge gained in the course of the experiments. The fact that when elements combine compounds altogether different in properties from the constituents are formed also meets with manifold illustration. Too little has been ascertained to admit of any general conclusion being arrived at with regard to the proportions in which elements combine, but it is clear that they may combine in more than one proportion since two oxides of carbon have been discovered, and in the only cases studied—viz. copper oxide and chalk—the composition has been found not to vary. The existence of various types of compounds has been recognised, and a good deal has been learnt with reference to the nature of chemical change. But, above all, the method of arriving at a knowledge of facts has been illustrated time after time in such a manner as to influence in a most important degree the habit of mind of the careful student. New facts have been discovered by the logical application of previously discovered facts: the habitual and logical use of facts has been inculcated. This is all-important. It has become so customary to teach the facts without teaching how they have been discovered that the great majority of chemical students never truly learn the use of facts; they consequently pursue their daily avocations in a perfunctory manner, and only in exceptional cases manifest those qualities which are required of the investigator; their enthusiasm is not awakened, and they have little desire or inclination to add to the stock of facts. It must not for one moment be supposed that the object of teaching chemistry in schools is to make chemists. Habits of regulated inquisitiveness, such as must gradually be acquired by all who intelligently follow a course such as has been sketched out, are, however, of value in every walk of life; and certainly the desire to understand all that comes under observation should as far as possible be implanted in everyone.

STAGE V.—*The quantitative stage.*

The *quantitative* composition of many of the substances which have previously been studied qualitatively should now be determined—in some cases by the teacher in face of the pupils, so that every detail may be observed and all the results recorded; in other cases by the pupils.

The composition of water is first determined by Dumas' method; this may easily be done, and fairly accurate results may be obtained in the course of a couple of hours. The results obtained by Dumas and subsequent workers should then all be cited, and, attention having been drawn to the extent to which such experiments are necessarily subject to error, the evidence which the results afford that hydrogen and oxygen combine in certain *fixed and invariable proportions* to form water is especially insisted upon.

The composition of chalk gas is next determined; this also is easily done, as impure carbon (lampblack) may be burnt and the hydrogen allowed for. Again, attention is directed to the results obtained by skilled workers, and the evidence which they afford that chalk gas never varies in composition.

The composition of copper oxide has already been ascertained; it may be re-determined by reducing the oxide in hydrogen: in fact, in determining the composition of water.

The lead oxides may be reduced in a similar manner, the oxide obtained by igniting white lead as well as red lead and the brown oxide obtained by acting on red lead with nitric acid being used. In this way it is ascertained that the brown oxide is the highest oxide; the loss in weight which this oxide suffers when ignited may then be determined.

Tabulating the results thus obtained, after calculating with what amount of the particular element that quantity of oxygen is associated which in water is combined with one part by weight (*unit weight*) of hydrogen, numbers such as the following are obtained:—

1	part of	hydrogen	is combined	with	8	parts of oxygen in	water
3	„	carbon	„	„	8	„ „	chalk gas
31·5	„	copper	„	„	8	„ „	copper oxide
103·5	„	lead	„	„	8	„ „	lead oxide (litharge)
51·8	„	„	„	„	8	„ „	„ (brown)

These clearly illustrate the fact that elements combine in very different proportions, and the results obtained with the lead oxides afford also an illustration of combination in multiple proportion.

The amounts of silver and lead nitrates formed on dissolving silver and lead in nitric acid are next determined by evaporating the solutions of known weights of the metals in porcelain crucibles on the water-bath, and then drying until the weight is constant; accurate results may be easily obtained, and these two exercises afford most valuable training. The nitrates are subsequently evaporated with muriatic acid and the weights of the products determined. What are these products? Does the metal simply take the place of the hydrogen in hydrogen chloride as zinc does when it dissolves in muriatic acid? If so, the products are silver and lead chlorides, and it may be expected that the same substances will be obtained—that the same increase in weight will be observed, when, say, silver is combined directly with chlorine as when it is dissolved in nitric acid and the solution is precipitated with muriatic acid or salt. Silver

is, therefore, heated in chlorine, and is found to increase in weight to the same extent as when it is dissolved in nitric acid, &c.; a given weight of silver precipitated by salt is also found to increase to the same extent as when it is directly combined with chlorine. The composition of silver chloride having thus been ascertained, the amount of chlorine in salt is determined. The composition of salt being ascertained, purified dried washing soda is converted into salt, and also the amount of chalk gas which it contains is determined: from the data, the composition of sodium oxide may be calculated. In like manner the composition of lime may be ascertained by converting chalk into chloride by igniting it in hydrogen chloride, and then determining the chlorine in the chloride; the same method may be applied to the determination of the composition of the oxides and chlorides of zinc, magnesium, and copper.

Discussing these various results, and comparing the quantities of oxygen and of chlorine which combine with any one of the metals examined, it is seen that in every case about 35·4 parts of chlorine take the place of eight parts of oxygen. Combination in *reciprocal proportions* is thus illustrated, and by considering the composition of chalk and washing soda it may be shown that this applies equally to compounds of two and to compounds of three elements. As 35·4 parts of chlorine are found in every case to correspond to eight parts of oxygen, it is to be expected that hydrogen chloride contains one part of hydrogen in combination with 35·4 parts of chlorine; a solution containing a known weight of hydrogen chloride is, therefore, prepared by passing the gas into a tared flask containing water and the chlorine is then determined.

It being thus clearly established what are *equivalent* weights of elements, the conception of equivalents may be further developed by exercises in acidimetry carried out by the pupils themselves. The proportions in which washing soda and hydrogen chloride interact may be determined by mixing solutions of known strength until neutralisation is effected; if the solution be evaporated and the chloride weighed, the results may be used in calculating the composition of hydrogen chloride; they serve, in fact, as a check on the conclusions previously arrived at as to the composition of washing soda and hydrogen chloride. Solutions of sulphuric and nitric acid may be similarly neutralised, and, the amounts of sulphate and nitrate formed having been ascertained, the equivalents of the acids may be calculated on the assumption that the action is of the same kind as takes place in the case of hydrogen chloride. Determinations of the strengths of acids, &c., may then be made. In a similar manner the volumetric estimation of silver may be taught and the percentage of silver in coinage and other alloys determined.

Such a series of quantitative exercises as the foregoing, when carried out *before* and to a considerable extent *by* the pupils, undoubtedly affords mental discipline of the very highest order, and is effective of good in so many ways that the value of such teaching cannot be over-estimated. The failure to grasp quantitative relationships which examiners have so frequently to deplore is without question largely, if not alone, due to students' entire ignorance of the manner in which such relationships have been determined. Moreover, the appreciation by the general public of the principles on which quantitative analysis is founded would certainly be directly productive of good in a multiplicity of cases.

STAGE VI.—*Studies of the physical properties of gases in comparison with those of liquids and solids. The molecular and atomic theories and their application.*

A series of quantitative experiments on the effect of heat on solids, liquids and gases should now be made, and these should be followed by similar experiments on the effect of pressure; the similar behaviour of gases, and the dissimilar behaviour of liquids and solids, is thus made clear. The condensation of gases is then demonstrated and explained, and also the conversion of solids and liquids into gases, and the dependence of boiling-point on pressure and temperature. Regnault's method of determining gaseous densities is studied, and the method of determining vapour densities is illustrated. The molecular constitution of a gas is now discussed; the phenomena of gaseous and liquid diffusion are studied and a brief reference is made to the kinetic theory of gases; then Avogadro's theorem is expounded and applied to the determination of molecular weights; and eventually the atomic theory is explained, and the manner in which atomic weights are ascertained is brought home to the pupils. The use of symbols must then be taught. Finally, the classification of the elements in accordance with the periodic law should be explained.

It is all-important that at least a large proportion of the experiments in each of the stages should be made by the pupils; but even if this were not done and the lessons took the form of demonstrations, much valuable instruction might still be given.

The majority of pupils probably would not proceed to the fifth and sixth stages; but those who perforce must terminate their studies without gaining any knowledge of chemical philosophy should unfailingly be led to make a few simple quantitative experiments: for example, to determine silver volumetrically, and the method of determining the composition of water and chalk gas should be demonstrated in their presence: and it may be added that if only the examples in Stages I. and II. and Problems I. to V. of Stage III. were thoroughly worked out, most important educational training would be given and much valuable information as to the nature of common phenomena would be gained.

The complete course would undoubtedly take up considerable time, but so does a satisfactory mathematical or classical course of study, and it is absurd to suppose that useful training in science is to be imparted in a few months. If instruction be given in the manner suggested at all generally, it will be necessary, however, to modify the present system of testing results. Pupils could not be expected to pass at an early age examinations such as are at present held, and awards would have to be based chiefly on an inspection of the classes at work and of note-books and on *vivâ-voce* questioning. But all are agreed that the present system of payment on results tested by a terminal examination is a most unhealthy one, and that a more rational system *must* be substituted for it. I may suggest that if members of the staff of science colleges, such as are now established in so many towns, could be appointed *supervising inspectors*, whose duty it would be to advise teachers in schools and *occasionally* to inspect the teaching in company with the permanent inspector, it would be possible to secure the assistance of a body of men who are in touch with scientific progress and conversant with the improvements which are being effected. A man who 'once an inspector is always an inspector' of necessity must get into a rut, and will escape from the wholesome

leavening and rousing influence which is always more or less felt by those whose office it is to follow the march of scientific progress.

It should also here be pointed out that the great majority of the experiments and exercises described may be carried out with very simple apparatus and with slight provision in the way of special laboratory accommodation. In but very few cases is there any production of unpleasant smells or noxious fumes. It is, in fact, a mistake to suppose that an elaborately fitted laboratory is in every case essential for successful teaching: much might be done in an ordinary schoolroom provided with a demonstration bench for the use of the teacher, a draught closet over the fire-place, a sink, a raised table for balances (raised so that the teacher might see what was going on), a cupboard for apparatus, and a long narrow bench provided with gas burners at which, say, twenty pupils might stand ten a side. At present the Science and Art Department will not recognise 'practical chemistry' unless it be taught in a laboratory fitted up in a certain specified manner, and their regulations are such as to enforce the provision of expensive laboratories in all cases where it is desired to obtain the grant. If greater latitude in fittings were allowed, more attention being paid to the character of the work done and less to the tools with which it is accomplished, probably much less money would be wasted by inexperienced school authorities in providing special laboratories, and there would be much greater readiness displayed to enter on the teaching of experimental science. The course which has been sketched out is one which doubtless might well be modified in a variety of ways according to circumstances. Thus many simple exercises in mechanics, in addition to those directly mentioned, might be introduced into Stage II., and the mechanical properties of common materials might be somewhat fully studied at this stage in districts where engineering trades are largely established, and where such knowledge would be specially valuable. In like manner the physical effects of heat on substances might be studied in Stage III. instead of Stage VI. And there are other chemical problems and simple exercises besides those described which might be substituted for some of them, or included in the course.

Probably, however, it would be found undesirable, if not impossible, as a rule, to continue the teaching of chemistry proper much, if at all, beyond the stage indicated in this scheme. Other subjects will have a prior claim should it ever be deemed essential to include in a comprehensive scheme of school education the elements of the chief physical and biological sciences; it certainly is of primary importance to introduce at as early a period as possible the conception of energy, and to explain the mechanical theory of heat, so that later on it may be possible to discuss the efficiency of heat and other engines; and, until the laws of the electric current are understood, the subject of chemical change can never be properly considered.

In many cases, where it is convenient or desirable to continue the chemical studies, it probably will be advantageous as a rule that they have reference to specific (local) requirements—*e.g.*, to agriculture in schools in agricultural districts; to food materials and physiology in the case of girls especially, &c. But in any case more consideration must be paid in the future in schools where chemistry is taught to educational requirements—the teaching must have reference to the requirements of the general public; and it must be remembered that the college, not the school, is the place for the complete study of a subject.

With the object of presenting in an available form information as to the position occupied by chemistry in Board and other Public Elementary Schools, which are controlled either by the Education Department, Whitehall, or the Science and Art Department, South Kensington, the Committee now present a report on the subject which has been prepared by Professor Smithells. A consideration of this statement will show that, as in the higher grade public schools, with which the Report of the Committee last year was chiefly concerned, the condition of the teaching in public elementary schools is far from satisfactory. As a rule chemistry is not taught on the proper lines. The pupils frequently receive the same kind of instruction in chemistry as they would at a later stage if they were preparing for a professional or technical career; consequently the subject has failed to provide that mental education which it should be the main object of elementary teaching to develop. It appears, too, that in many of these schools physical science has not hitherto been regarded as a necessary part of the educational scheme. It is essential that this state of affairs should be altered, and that physical science should occupy a more favourable position in the Education Code, and that its teaching should be more thoroughly controlled.

It is to be hoped also that the Education Department, as well as the Science and Art Department, South Kensington, will take steps to arrange a more efficient mode of inspecting science teaching than that at present in vogue, which can only be regarded as satisfactory from a purely statistical standpoint. Under the present system little or no control can be exercised over the science teaching, since the Whitehall Inspectors are, as a rule, not qualified to form an opinion as to its value. There would seem to be no difficulty in obtaining the services of properly qualified persons to act as additional inspectors for the purpose of reporting on the character of the science teaching. It is probable that many of the professors and lecturers in University Colleges, and other educational institutions, might be willing to take part in such inspection, and it would thus become possible to maintain a high standard of excellence in the teaching.

The Teaching of Chemistry in Public Elementary Schools.[1] *Drawn up by* Professor Smithells.

In view of the rapid increase in the teaching of chemistry in connection with public elementary schools likely to take place, chiefly on account of the establishment of the so-called 'Higher Grade Board Schools,' and in view of the strenuous attempt that is being made to extend the teaching of science subjects by a separate Act dealing with technical instruction, it seemed of importance to prepare a short statement indicating the position occupied by chemistry in our state-aided elementary schools. Since the chemical teaching in such schools is practically dominated by the syllabus of the Education Code and of the Science and Art Department, any improvements or suggestions the central authorities at Whitehall or

[1] *I.e.*, in Voluntary and Board Schools receiving grants from the Education Department under the Education Acts.

South Kensington could be induced to accept would at once take effect throughout public elementary schools dealing with four and a half millions of children, or between one-sixth and one-seventh of the total population.

The following statement deals with the conditions under which chemistry is taught in Voluntary and Board Schools, and with the extent of such teaching, in England and Wales only. Notes are added with reference to chemistry teaching under the Scotch Education Department, and to other matters relating to the main question.

The Education Code.—The subjects of instruction in the Education Code are divided into three classes:—

1. Elementary or Compulsory Subjects.—Reading, Writing, and Arithmetic (and Needlework for girls).

2. Class or Optional Subjects.—English, Geography, Elementary Science, History, Singing, or other graduated subject approved by the Inspector.

3. Specific Subjects.—Algebra, Euclid and Mensuration, Mechanics, Chemistry, Physics, Animal Physiology, Botany, Principles of Agriculture, Latin, French, Domestic Economy, and other subjects approved by the Inspector.

All schools must take the elementary subjects in all the standards.

Not more than two class subjects may be taken, one being English. (In the case of girls the second class subject must be needlework unless taken under the head of elementary subjects.)

The specific subjects are only to be taken in the upper classes of a school, viz., in Standards V., VI., and VII.

There is in the Code as it stands the possibility of an excellent course of instruction in elementary chemistry. It would really begin in the infant school with enlightened object lessons and kindergarten work, then in the elementary school proper it could be continued in the first four standards as the class subject 'elementary science,' lastly in the V., VI., and VII. Standards as the specific subject chemistry.

The teaching in the infant schools is not circumscribed by detailed schedules or individual examination, and is admittedly the most satisfactory part of our educational system.

The schedule for elementary science as a class subject is as follows:—

——	Standard I.	Standard II.	Standard III.
III. Elementary Science A progressive course of simple lessons on some of the following topics, adapted to cultivate habits of exact observation, statement, and reasoning	Common objects, such as familiar animals, plants, and substances employed in ordinary life.		

Standard IV.	Standard V.	Standard VI.	Standard VII.
A more advanced knowledge of special groups of common objects, such as— (*a*) Animals or plants with particular reference to agriculture (*b*) Substances employed in arts and manufactures (*c*) The simpler kinds of physical and mechanical appliances, *e.g.*, the thermometer, barometer, lever, pulley, wheel and axle, spirit level	(*a*) Animal or plant life (*b*) The chemical and physical principles involved in one of the chief industries of England, among which agriculture may be reckoned (*c*) The physical and mechanical principles involved in the construction of the commoner instruments, and of the simpler forms of industrial machinery	The preceding in fuller detail	The preceding in fuller detail

Chemistry as a specific subject taken by boys in the V., VI., and VII. Standards is divided into three 'stages' as follows, each stage representing one school-year's work:—

Stage I.	Stage II.	Stage III.
Elementary and compound matter. Illustrations of combination and decomposition in such bodies as hydrochloric acid, water, oxide of mercury, and rust of iron	Preparation and properties of the common gases, such as oxygen, hydrogen, nitrogen, and chlorine The chemical character and constituents of pure air and pure water, and the nature of the impurities sometimes found in both. Effects of plants and animals on air	The properties of carbon and its chief inorganic compounds. Differences between metallic and non-metallic bodies. Combination by weight and volume. The use of symbols and chemical formulæ

Any *further teaching* of chemistry than the above would not earn Government grants from the Education Department, but might be provided by school managers in extra classes or in a so-called Higher Grade School by money from the school funds or the rates (according as it were a Voluntary or Board School) and by means of grants obtained from the South Kensington Science and Art Department under conditions to be subsequently explained.

Inspection and Grants.—The teaching of the science in all stages would be subject to the inspection of one of H.M. Inspectors of Schools, on whose annual report the Government grant would be awarded. The examination, conducted once a year, in the elementary science is oral, and may be conducted as the Inspector likes. If the class is reported 'fair' a grant of 1*s.* per head is allowed, if 'good' 2*s.*, and besides this the quality of work done in the class subject is considered in awarding the 'merit grant,' *i.e.*, a grant awarded to the school on the general merits of the organisation, teaching and discipline, 1*s.*, 2*s.*, or 3*s.*, according as it is 'fair,' 'good,' or 'excellent.'

In 1887–8, 25,000 out of 4,500,000, *i.e.*, 1 in 180, children in schools took this subject.

The teaching of chemistry as a specific subject is also under the control of H.M. Inspectors, who award a grant of 4*s.* on each pupil who passes at the annual written examination. The performance in specific subjects also counts in awarding the merit grant.

Teachers and Apparatus.—The teachers in the earlier standards (including elementary science) are the usual school teachers, and have not necessarily any qualification of a scientific kind.

The inspectors have instructions to ascertain that teachers of *specific* subjects have received training in a training college or have passed some public examination. The Department recommends the 'peripatetic' system of science teaching by a 'demonstrator,' in which either the demonstrator visits the schools in rotation, or the pupils from the different schools attend a central laboratory for science instruction. This system has been adopted with success in several large towns, including London, Liverpool, Manchester, Birmingham, and Leeds.

There is no stipulation in the Code for apparatus or experimental illustration, this being a matter for the school managers, subject to the criticism of the inspectors.

Statistics.—The following are statistics as to the teaching of chemistry in elementary schools as a specific subject under the Whitehall Code for the year 1887–8 :—

—	Total No. examined	Passed	Percentage	1st stage	2nd stage	3rd stage
Voluntary Schools . . .	453	327	72·2	181	127	19
Board Schools	1035	750	72·5	409	295	46
Total	1488	1077	—	590	422	65

—	Average number of scholars in attendance in all subjects	Proportion taking Chemistry (specific)
Voluntary Schools . .	2,216,854	about 1 in 5,000
Board Schools . . .	1,327,710	„ „ 1,280

The proportion taking chemistry in Board schools is thus about four times that in Voluntary schools.

Chemistry as a Science Subject.—The preceding statements apply only to teaching under the Whitehall Education Department. The greater part of the chemistry teaching is carried out under the Science and Art Department, South Kensington. This is done in virtue of a regulation of that Department, whereby pupils in elementary schools receiving aid from the Whitehall Education Department may be 'registered' in a science subject provided that they have passed Standard VI. of the Code and are taught by a duly qualified teacher. Such teacher must have obtained a first class in the advanced stage of the May examinations of the Science and Art Department, or have obtained some qualification deemed equivalent by the Department.

Pupils who have passed Standard VI. may thus form a class under

the Science and Art Department, and present themselves at the usual May examinations in chemistry.

For every pass in the elementary or advanced stage a payment of 2*l.* for a first class and 1*l.* for a second class is made, subject to a deduction of 4*s.* if the same pupils have within the previous six months been examined and have obtained grants through the Whitehall Department for chemistry as a specific subject.

For honours 4*l.* and 2*l.* for a first and second class respectively are granted.

In practical chemistry the following grants are made:—

2*l.* and 1*l.*	for first and second	class	elementary	respectively
3*l.* ,, 2*l.*	,,	,,	advanced	,,
4*l.* ,, 3*l.*	,,	,,	honours	,,

The conditions are:—

(*a*) That the teacher is qualified as above.

(*b*) That he has given at least 28 lessons during the session.

(*c*) That each candidate has received 20 lessons.

(*d*) That the candidate does not present himself in more than two subjects.

Stringent conditions are also made as to laboratory accommodation and the provision of apparatus, and grants are made for these purposes.

The teaching is under the inspection of the South Kensington inspectors, who are only four in number. They are assisted by 'acting inspectors,' consisting of officers of the Royal Engineers, who may inspect classes in the neighbourhood where they are for the time stationed. Such inspection is, however, as a rule, merely 'statistical' as to apparatus and laboratory fittings.

The syllabus of the examinations which regulate the teaching are too well known to need repetition here. They have been much improved in recent years by the creation of an 'alternative first stage,' consisting of a course of chemistry of common things.

An outline of suitable experiments for illustrating the courses, drawn up by Sir Henry Roscoe and Dr. Russell, is issued by the Department for the guidance of science teachers.

Organised Science Schools.—The teaching of chemistry in elementary schools is further influenced by the Science and Art Department by means of 'organised science schools.' Under the regulations of the Department the scholars of an elementary school (provided that it is not receiving aid from the Whitehall Department on their account) may be formed into an organised science school. For this purpose a course of purely scientific instruction (with the addition of drawing) is laid down. The course includes substantial instruction in chemistry.

For the pupils of such schools who register 250 attendances on the full course, and pass in one subject proper to each year, a capitation grant of 10*s.* is made in addition to what may be earned at the usual May examinations. Payments are not made for more than four years. The conditions are somewhat different for evening schools.

'Organised Science Schools' exist in some large towns, as Birmingham, Manchester, Leeds, Brighton, and Middlesborough, the total number in the country being twenty-three.

Statistics.—The following statistics show the number of pupils receiving instruction in chemistry in classes registered under South Kensington,

and the number of such who are also studying the subject in public elementary schools.[1]

—	Total number of individuals registered under South Kensington	Total number of scholars of Public Elementary Schools registered under South Kensington
Inorganic (theory) . .	14,241	8,202 (in 134 schools)
„ (practical) . .	6,155	
Organic (theory) . .	1,244	
„ (practical) . .	926	
Total taking theoretical Inorganic and Organic	15,485	8,202

Taking the above figures, in conjunction with those given on p. 254, for the teaching of chemistry as a specific subject, we may say that in the public elementary schools of England and Wales there were during the last school year about 10,000 scholars receiving instruction in chemistry, or about 1 in 364 in average attendance, or 1 in 450 on the total number of children on the register.

In the Appendix more detailed information is given as to the teaching of chemistry in one or two large towns.

Difficulties in the way of Chemical Teaching in Public Elementary Schools.—Although a satisfactory course of instruction in chemistry might be based on the Code, it is seldom done. Children on leaving the infant schools pass into the standards where elementary science is only an optional subject. The first optional subject must be English, and if a second is taken it is usually geography, and in most schools—as, for example, in those of the Leeds district—there is practically no 'elementary science' taught in the first four standards.

When children arrive at Standard V. they may take chemistry as a 'specific' subject, but several difficulties are met with, of which the following are the chief:—

1. Between the infant school and the Fifth Standard there is generally a gap of four years, during which the faculties of observation have received no training, and the good beginning made in the infant school has not been followed up.
2. The expense and trouble of preparing experiments. This may, for example, lead to the teaching of physiology (by diagrams only) instead.
3. The smallness of the grant obtainable (4*s.* for a pass).

The third difficulty is partly overcome by school authorities making the teaching of chemistry as a specific subject preliminary to the classes held under South Kensington, the pupils of which obtain substantial grants; but a difficulty is experienced in co-ordinating the Code Schedule with the South Kensington syllabus, so that pupils on reaching Standard VI. may be only just ready for the South Kensington examinations in the following May. If a pupil is taught chemistry as a 'specific' subject

[1] From a return kindly furnished by Major-General Donnelly, Secretary of the Science and Art Department.

in Standard V. for one year, he is usually ready for the elementary stage South Kensington examination, but is not admissible for another year. (If the 'Class' subject 'elementary science' were taken in Standards I. to IV., as is so desirable, this difficulty would be further increased.)

Most boys on reaching Standard VI. leave school, so that they do not take the South Kensington examinations, which is the only way for the school to earn the substantial grants which make science teaching 'pay.'

In consequence of these difficulties surrounding the teaching of chemistry as a 'specific' subject under the Whitehall Department, the greater part of the chemical teaching in elementary schools is forced under the South Kensington Science and Art Department, and school boards are being led to establish higher-grade schools, confined to boys who have passed the Sixth Standard and are able to prepare for the South Kensington examinations. They include those boys whose parents are of sufficiently good means to keep them at school after the age of fourteen. Such schools are regarded by many as going beyond the elementary education contemplated in the Education Act of 1870.

Conclusions.—Reviewing the foregoing statements, which I have endeavoured to keep free from merely personal opinions, I am led to the following conclusions:—

(1) That the teaching of chemistry in public elementary schools is far from satisfactory in its organisation.

(2) That the teaching of chemistry in public elementary schools from its earliest stages in the infant schools to its latest stages in higher-grade schools should be under the control of one Educational Department only.

(3) That if, as is admitted, the teaching of chemistry, if adopted at all, should be used as a part of general mental discipline, its organisation and control should not be separated from that of other branches of elementary education, that is to say, it should be conducted under the Whitehall Education Department.

(4) That the present inspectorate is ill-adapted for the supervision and control of chemical teaching, and that special or additional inspectors, suitably qualified, should be appointed.

(5) That the Code regulations should be so amended as to give 'elementary science' more chance of being adopted as a 'class or optional' subject—*e.g.*, by incorporating geography and elementary science as one subject.

(6) That the minimum qualifications for science teachers are too low, for, though it is possible for such teachers to inculcate facts, a high standard of scientific knowledge is absolutely necessary for the proper 'educative' teaching of the most elementary chemistry.

(7) That the peripatetic system is at present the only practicable way of obtaining sufficiently good chemical teaching.

(8) That the science teaching in the Universities and University colleges should be made available for the training of teachers of chemistry in public elementary schools.

(9) That, as a rule, chemistry is presented to children in elementary schools in precisely the same way as to undergraduates in the Universities, and that this is the chief cause of unsatisfactory results.

(10) That the routine schematic teaching of qualitative analysis which constitutes usually the 'practical chemistry' of schools, though pleasing and interesting to the pupils, is most unsatisfactory and uneducative.

(11) That there is urgent need of some book, or at least instructions, which shall show how chemistry may be approached naturally and logically from a study of common things and every-day phenomena.

(12) That great latitude should be allowed to the teacher to work out a system of the kind indicated, suitable to the conditions under which he works.

(13) That the teaching of chemistry as a specific subject cannot be expected to thrive in public elementary schools with only a 4*s.* grant as against the much larger sum obtainable from South Kensington, and that the Government grant should be awarded, not on individual written examination, but on oral examination combined with general supervision of the character of the teaching.

(14) That true specialised technical or professional training in chemistry should not be attempted, but that it should begin not earlier than in recognised state-aided secondary schools, restricted to such scholars as have qualified themselves by a regular and satisfactory course in an elementary school.

Very exaggerated notions exist, and are becoming more and more prevalent, as to what may be properly attempted so far as the teaching of chemistry in elementary schools is concerned. The public do not realise that in the countries where science is most cherished and applied most extensively and successfully to industry (*e.g.*, Germany and Switzerland), the chemical and science teaching in the *elementary* schools is of the most simple and general character, and that the systematic teaching of science for technical purposes begins only in higher schools, polytechnics, and universities. This systematic teaching depends for its success no more on the previous training in science than on the previous training in arithmetic. It demands solely that the previous training shall not have given merely *information*, but that it shall have developed *intelligence*, that it shall have been rational and thorough, and have been administered by good teachers. In this country too much or too little is being attempted, and it is quite a common thing to find boys possessing a large amount of detailed 'information' about chemistry, and a certain mechanical aptitude in chemical analysis, who are unable to do a sum in simple proportion or to write their own language correctly.

The most that can be properly aimed at in teaching chemistry in elementary schools is the training of the faculties of observation and of orderly thinking, and the stimulation of the instinct of inquiry, which is the possession of every 'uneducated' child. By restricting the teaching to common things and occurrences this can easily be done, and so an interest aroused both in the phenomena of nature and in those involved in industrial operations. In this way there will be created an interest in and appreciation of chemistry amongst the many and preparation made for the few who can proceed to the highest study of the subject, which alone is *directly* applicable to the advancement of industry.

APPENDIX.

I. *Chemistry in the London Board Schools.*[1]

The teaching of chemistry in the London Board schools calls for special remark, in view of the comprehensive scheme of 'systematised object

[1] For this information I am much indebted to Dr. J. H. Gladstone, F.R.S.

lessons, embracing in the six school years a course of elementary instruction in physical science, and serving as an introduction to the science examinations which are conducted by the Science and Art Department.' This system has been in vogue for some years and constitutes the optional subject—'elementary science'—of the Code. It is continuous with the object lessons of the infant schools, and bridges over the usual gulf between these and the 'specific' science subjects. The following is a model scheme suggested by the School Management Committee of the London School Board:—

Standard I.	Standard II.	Standard III.	Standard IV.
Extension of the object lessons in the infant school, with simple illustrative experiments	Comparison of different plants or animals Ordinary phenomena of the earth and atmosphere Substances of domestic use	Simple principles of classification of plants and animals Further phenomena of the earth and atmosphere Substances used in the arts and manufactures	More complete classification of plants and animals, with typical examples The three forms of matter familiarly illustrated

Standard V.	Standard VI.	Standard VII.
(*a*) Animal and plant life, with the most useful products; or, (*b*) More definite notions of matter and force illustrated by simple machinery or apparatus	(*a*) Animal and plant life, with special reference to the laws of health; or, (*b*) The commonest elements, and their compounds The mechanical powers	(*a*) Distribution of plants and animals, and the races of mankind; or, (*b*) Light, heat, and electricity, and their applications

The scheme is adopted wholly or partially in a considerable number of London Board schools. It is encouraged by the Board providing the rarer objects and offering a museum cabinet to any school in which a good commencement of a collection has been made. It will be seen that the course of instruction embodies a considerable amount of elementary chemistry.

The teaching of chemistry as a specific subject calls for no special remark. It is only adopted in ten schools, and no special teachers are provided.

The systematic teaching of mechanics ('in a large sense') by four peripatetic demonstrators is a very important feature in London Board schools. 'The science demonstrator gives a lesson fortnightly to the boys in the fifth and higher standards, the lesson being illustrated experimentally by specimens and apparatus carried from school to school.' This system is being widely adopted in the London School Board district, but is scarcely yet beyond the experimental stage. Its prevalence accounts

largely for the small amount of chemical teaching, but this is also attributed to the fact that chemistry is not of the same relative importance in London arts as in those of other large towns.

At the annual examination in 1888, 341 pupils passed in chemistry as a specific subject out of an average of 51,214 boys and girls in attendance on one or other of the fourteen 'specific' subjects, or a total of about 420,000 children on the school registers.

In the evening schools chemistry is taught on the lines of the South Kensington syllabus, but only to a very slight extent, the number in attendance not exceeding 100 in 1887–8.

In the pupil-teachers' schools chemistry is also taught according to the syllabus of the elementary or alternative elementary stage of South Kensington.

II. *Chemistry in Birmingham Board Schools.*

In the thirty-four Birmingham Board schools, with an average attendance of 38,000, all boys receive instruction in 'Elementary Science' in Standards V. and VI. Thus 2,700 boys learn mechanics, 550 magnetism and electricity. 2,200 girls learn portions of chemistry and physiology under the name of Domestic Economy. The instruction is given by a peripatetic demonstrator and four assistants, who give a lesson once a fortnight to each school. The lesson is recapitulated by the class-teacher, and the children reproduce it in a composition.

The teaching of chemistry as a distinct subject begins in a central Seventh Standard school, in which there are 200 scholars, with a headmaster and five assistants.

In May 1887, at the South Kensington examinations, 110 scholars were presented in theoretical inorganic chemistry, of whom only seven failed; in practical inorganic chemistry 112 were presented, 17 failed.

III. *Chemistry in Manchester public elementary schools.*

(From a return issued by the Manchester Branch of the National Association for the Promotion of Technical Education.)

Day schools:

Chemistry as a 'specific' subject.

Board Schools	159 scholars.
Voluntary Schools	5 ,,
Total	164 ,,

Chemistry as a science subject (under South Kensington).

—	Inorganic (theory)	Inorganic (practical)	Organic (theory)	Organic (practical)
Board Schools . . .	447	424	40	40
Voluntary Schools . .	23	—	—	—
Total . . .	470	424	40	40

Evening schools:

Chemistry as a science subject (under South Kensington).

—	Inorganic (theory)	Inorganic (practical)	Organic (theory)	Organic (practical)
Board Schools . . .	262	206	39	28
Voluntary Schools . .	47	23	—	—
Total . . .	309	229	39	28

Probably not less than 1,000 pupils are receiving instruction in chemistry in these public elementary schools.

The teaching is in higher-grade schools, and also by means of peripatetic demonstrators.

There is laboratory accommodation provided by the Manchester School Board for 184 students; by the Salford Board for 70.

IV. *Chemistry in the grant-earning public schools of Scotland.*[1]

So far as science teaching is concerned, the provisions of the Scottish Education Code are similar to those of the English Code.

Very little 'elementary science' appears to be taught, and in chemistry, as a specific subject, only 350 scholars obtained grants in 1888–9.

A considerable amount of teaching is done in connection with South Kensington, but I have been unable to obtain exact statistics.

There are no higher-grade Board schools in Scotland, as the Scotch School Boards have the control of many old-established secondary schools, such as the High Schools of Edinburgh and Glasgow. In some of these efficient instruction is given in special sciences.

The Technical Education (Scotland) Act of 1887 is so far a dead letter.

V. *Teachers of chemistry in public elementary schools and their training.*

The following classes of teachers are recognised by the Education Department:—

Pupil teachers, assistant teachers, provisionally certificated teachers, certificated teachers, teachers of evening schools, and, by the Science and Art Department, science teachers.

It has already been stated that teachers of 'elementary science' in the first four standards need not have passed any examination in science, nor are the inspectors enjoined to inquire particularly into the previous training of such teachers.

As to chemistry as a specific subject, the inspectors are instructed that it will be desirable for them to ascertain that the teacher has given proof of his fitness to teach by having acquitted himself creditably at a training college or at some other public examination.

The chemistry teaching in training colleges[2] is under the regulations of South Kensington. The students, unless possessing previous know-

[1] I am indebted to Professor Carnelly for information on this subject.

[2] *I.e.*, colleges for teachers in public elementary schools only.

ledge of the subject, are intended to have two years' training, of which instruction in practical chemistry and the performance of 'the more important and characteristic of the experiments' are a necessary part. In December of each year an examination is held, on the results of which all payments on behalf of instruction in science in training colleges are made. This examination is based on the syllabus of the ordinary May examinations; but the standard is somewhat higher, and special questions are set on the method of teaching. Students who pass on the advanced paper or in honours are registered as qualified to earn payments on results.

At Christmas 1887 297 students in training colleges presented themselves for this examination in inorganic chemistry, of whom 76 passed in the first division, 172 in the second division, and 49 failed. In practical chemistry, of 190 candidates 47 obtained a first class, 96 a second class, and 47 failed.

Any person over eighteen years of age approved by the inspector may become a teacher in evening schools.

The simplest qualification for a teacher of chemistry as a science subject under South Kensington was, until recently, the obtaining of a second class in the advanced stage at the May examinations in that subject. This is now raised to a first class. The other qualifications considered equivalent by the Department need not be enumerated, except the most important one, viz., that the teacher has been trained at the Normal School of Science and Royal School of Mines. For details of the curriculum reference must be made to the Science Directory.

Certain grants and privileges are allowed to science teachers who have proved themselves specially meritorious. These are briefly—

(*a*) Payment of railway fare and 3*l.* to attend a free summer course of lectures at South Kensington; or

(*b*) Free admission to the classes of the Normal School of Science, railway fare, and 21*s.* or 30*s.* per week whilst in attendance; or

(*c*) Part payment ($\frac{3}{4}$ for day classes, $\frac{1}{2}$ for evening classes) of fees for classes taken at University colleges by selected teachers;

(*d*) Payment of expenses of a teacher taking a group of towns or villages;

(*e*) Admission of qualified teachers to classes at South Kensington at a fee of 1*l.* for each subject.

In the session 1886–7 there were at the Normal School of Science twenty-four teachers in training taking chemistry, in addition to a larger number of regular students, who will become eventually science teachers. Forty-seven science teachers attended the summer course in chemistry.

Forty-two teachers were selected to attend classes at University colleges, of whom only a part took chemistry.

In addition to the above methods of training teachers, school boards may themselves institute special classes. Thus in Leeds there has been during the past year a class for the instruction of elementary teachers and one for pupil teachers in theoretical and practical chemistry. Instruction was given by the science demonstrator to the School Board, and the attendance was 30 in the first class and 12 in the second. It would be very difficult to obtain complete statistics of the amount of this kind of teaching that is in operation throughout the country, but it does not appear to be very general.

VI. *The teaching of chemistry in evening schools under the Education Department.*

The chief points in which the administration of evening schools differs from that of day schools are as follows :—

1. No pupils may be presented for examination below the third standard.
2. In the third or fourth standard the first subject additional to the three R's must be English, and, if a second be taken, it must be geography or elementary science.
3. Above Standard IV. scholars are unrestricted in their choice of additional subjects.
4. A fixed grant of 4*s.* is made on the average attendance if the class has met not less than forty-five times, and of 6*s.* if not less than sixty times.

A grant of 2*s.* is made for every pass in an elementary or additional (*i.e.* class or specific) subject.

The total number of scholars on the register of evening schools in 1887–8 was about 50,000, of whom about two-fifths were in Board schools and three-fifths in Voluntary schools. One-seventh of the scholars were under fourteen years of age, and one-twentieth twenty-one and over. Nearly four-fifths were qualified for examination. About 1,200 passed in two additional subjects (*i.e.*, they may have taken a science subject).

More detailed returns are not published, but probably it is safe to say that less than 500 evening scholars took chemistry as a specific subject. This shows that the teaching of chemistry to evening scholars is almost entirely under the Science and Art Department.

VII. *Recommendations of the Royal Commission on Technical Instruction (Report 1884) affecting chemical teaching in public elementary schools.*

The Commissioners recommend—

(*a*) That science be given a more favourable position under the code by a reduction of the number of 'class' subjects to two in the lower divisions of schools, one of which shall be elementary science, including geography.

(*b*) That school boards have power to establish, conduct, and contribute to science classes for young persons and artisans under the Science and Art Department.

(*c*) That the teaching under South Kensington be made more practical in the higher stages and be subject to more thorough inspection; that payment of fees be not necessarily demanded from artisans, and that the building grants be not limited to 500*l.*

(*d*) That the teaching of science in training colleges be made more efficient and subject to better inspection, and that greater facilities be given for the students to pass on to the Normal School of Science or other place for higher scientific instruction.

(*e*) That secondary, 'modernised,' and technical schools should be established out of ancient endowments and by contributions from 'local authorities.'

VIII. *The Technical Education Bill* (1889) *and the teaching of chemistry in public elementary schools.*

This Bill, introduced by Sir Henry Roscoe on behalf of the National Association for the Promotion of Technical Education, would, if passed in its present form, make the following changes :—

(*a*) School boards or *local authorities*, or *both*, would be enabled to establish day or evening classes and provide laboratories, apparatus, and collections, &c., for the teaching of chemistry in public elementary schools *and to maintain them from the 'local rates,'* with aid from the Education or Science and Art Department, or both, under conditions to be defined by special minutes of the departments. Admission to such classes *would not necessarily be restricted to children above the fourth standard*, although power is given to impose an entrance examination in reading, writing, and arithmetic.

(*b*) School boards or local authorities might also contribute directly or by payment of the fees of deserving students or by means of scholarships to the aid of the teaching of chemistry *in any elementary, secondary, or technical school or in a college*, and grants in aid would be obtainable by schools from the Science and Art Department.

(*c*) Chemical instruction provided under this Act in public elementary schools would be under the inspection both of the Whitehall and South Kensington inspectors.[1]

The Technical Education Bill would thus affect the teaching of chemistry favourably as regards secondary and higher instruction, enabling the school boards and local authorities to make direct contributions to mechanics' institutes, technical schools, grammar schools, and colleges, as well as to their own technical classes in elementary schools. It is difficult to say how far it would affect the teaching of chemistry in *bonâ fide* elementary schools ; but it seems to aim either at encouraging the optional subject, elementary science, and the specific subject, chemistry, and increasing the grants on them indirectly, or at enabling children to receive chemical instruction of the South Kensington type in the early standards irrespective of the three R's. If the Bill passes in its present form, there will apparently be three ways of taking chemistry in an elementary school, viz. (1) as a specific subject under the Whitehall Department ; (2) as a science subject under South Kensington ; (3) as a technical subject under both. The educational aim is the same in all three cases, and it seems a great pity that the small amount of simple science teaching that is required for children in legitimate elementary schools should be so complicated in administration. It would seem that a simple alteration of the code is required to give a proper basis for technical instruction, and that a technical or secondary instruction Bill would be more fittingly limited to technical and secondary schools.

[1] The important innovations are italicised.

IX. *Recommendations of the Elementary Education Commission Report* (1888) *affecting chemical teaching.*

The recommendations in the recent report of the Elementary Education Commission are very favourable to science teaching, as may be seen from the following extract:—

'If it be true, as we believe it is, that the object of elementary instruction is to give such instruction to the scholars in general as will best fit them to fulfil the ordinary duties of life to which they are most likely to be called, and to enable those who may be endowed with special gifts to rise to still higher callings, then elementary instruction in science—and we lay special stress upon the word "elementary"—is only second in importance to elementary instruction in reading, writing, and arithmetic. But the fact has impressed itself upon our minds that technical training does not exist for boys even to the extent that instruction in needlework and cookery supplies it for girls. We have had, however, a great deal of evidence showing the educative effect of science teaching in elementary schools for both boys and girls; and we think that science, especially mathematical, mechanical, and physical science, is not only the foundation, but an essential part of thorough technical instruction.

'There are, however, certain broad principles to be laid down as necessary conditions of introducing science teaching into elementary schools. In the first place, care must be taken that it is not introduced too early in school life, lest it should interfere with the scholars' general instruction. In the second place, we are of opinion that, as a rule, the ordinary elementary master cannot be expected to be a good science master. Even in the case of an elementary teacher who, while at the training college, has made good progress in science studies, we consider that he has so much also to do in the usual school routine, and that his attention is so much distracted from science, that he cannot be relied on either for clear, vivid, and simple lectures, or for neatness and certainty in the performance of experiments. But to possess the power successfully to achieve these results is an essential qualification in a science teacher, and especially so in one who has to expound experimental science to the class who attend our elementary schools.'

In addition to general recommendations in the sense of the above quotation, the chief are—

(*a*) That object lessons should be continued in the lower standards in succession to similar teaching in the infant schools.

(*b*) That the system of peripatetic demonstrators should be encouraged.

(*c*) That more attention should be given to the possession of an adequate knowledge of natural science in the appointment of H.M. inspectors.

(*d*) That examinations in science should as far as possible be conducted orally, and not on paper, especially in the first five standards.

(*e*) That higher grades of elementary schools should be recognised as continuation schools.

(*f*) That technical instruction should be placed in the hands of, and mainly supported by, 'local authorities,' and be controlled by the Education Department.

(*g*) That the evening school system should be thoroughly revised so as to admit of (1) special curricula suitable to the locality; (2) attendance on 'additional subjects' without at the same time taking the three R's; (3) attendance of scholars over twenty-one years of age. Also that a greater fixed grant should be awarded, and less be made to depend on individual examination.

X. *The New Proposed Code* (1889) *and chemical teaching.*[1]

The chief changes contemplated in the New Code are as follows:—

(*a*) The grant on results of examination in the three R's is cancelled, and the merit grant disappears as a separate grant. The grants for elementary science and chemistry as a specific subject are, however, unaltered, *i.e.*, they are still based on results of individual examination.

(*b*) English is no longer compulsorily the first class subject, and the position of elementary science is thus improved.

(*c*) Scholars of any public elementary school may attend science classes at any place approved by the inspector, and still earn Government grants.

(*d*) Day training colleges are recognised. Teachers of chemistry may thus be trained in the existing University colleges with a Government capitation grant of 35*l.* per annum. The precise conditions are not yet defined. A third year of training is recognised for the first time.

(*e*) The conditions of age and grants are retained in evening schools, but a scholar who has passed Standard V. may be examined in 'additional' subjects—*e.g.*, chemistry without the three R's.

These alterations, together with other minor ones, give greater freedom to the teaching in elementary schools, and especially influence the teaching of chemistry (1) by releasing the pressure due to the necessary individual 'passing' in the three R's; (2) by making it possible for elementary science to be the first optional subject taken; (3) by allowing scholars to go outside for science instruction; (4) by making the chemistry teaching in University colleges available for the training of teachers.

The Code, however, as will be seen, falls short of the recommendations of the Elementary Education Commission so far as science teaching is concerned.

Postscript to Appendix.

The Technical Instruction Act (1889) *and chemical teaching.*

The Government Bill introduced and passed at the end of the recent session differs from Sir Henry Roscoe's Bill, referred to in the Appendix VIII., p. 264, in several respects. It provides mainly that the 'local

[1] See article by Dr. Gladstone, 'The New Code and Science Teaching,' *Nature*, May 2, 1889; also statement issued by the National Association for the Promotion of Technical Education, 'The New Education Code 1889.'

authority' (county or borough council or urban sanitary authority) shall have power to contribute money to all schools and institutions not conducted for private profit in aid of all the sciences and arts relating to industries and also in aid of manual instruction. The money is to be raised by a local rate not exceeding one penny in the pound in one year. The range of subjects of study and the relative aiding of different schools is to be regulated by the Science and Art Department. The effect of the Act will not be felt in the truly elementary schools, but it will greatly encourage the teaching of chemistry and other sciences to children who have passed the Standards.

From those who are engaged or interested in the teaching of physical science the Committee will be glad to receive any information which is likely to be of service in showing how their suggestions may best be carried into effect.[1]

The Committee ask to be reappointed.

Third Report of the Committee, consisting of Professors TILDEN *and* W. CHANDLER ROBERTS-AUSTEN *and* Mr. T. TURNER (*Secretary*), *appointed for the purpose of investigating the influence of Silicon on the properties of Steel.*

THE Committee, having asked Mr. R. A. Hadfield to assist them in this investigation, beg leave to present the result of a series of experiments kindly undertaken by him.

Alloys of Iron and Silicon.[2] *By* R. A. HADFIELD.

The alloying of elements other than carbon with iron is a comparatively new field, and possesses special interest, not only to those concerned and engaged in the treatment of metals, but also to those who study the physical properties of substances. As the nature of alloys of carbon and iron is fairly well understood, it is hardly necessary to consider them here, and in order to narrow down the considerations dealt with in this paper to a practicable limit, attention will be confined solely to alloys or mixtures of which metallic iron and silicon form the principal constituents.

An investigation of the properties of manganese steel, *i.e.*, an alloy of iron and manganese, was placed before the Institution of Civil Engineers and Iron and Steel Institute by the author some twelve months ago, and its physical properties have been fairly well determined as compared with alloys of iron with other elements. This was the more practicable owing to the fact that the manufacture of 'cast-iron' alloys of manganese—that is, ferro-manganese—has been for some time past in a very advanced state. In other words, by the cheap production of the alloys known as rich ferro-manganese—a material containing 80 per cent. of ferro-manganese, 5 per cent. to 7 per cent. of carbon, and the rest iron, has enabled experiments to be readily carried out by further alloying such rich manganese products with pure iron.

[1] It is requested that these communications be addressed to Professor Dunstan, 17 Bloomsbury Square, London.

[2] Abstract of a Paper presented to the Iron and Steel Institute.

Mr. Turner's paper, read before this Association at Bath last year, described experiments with steel containing from ·10 per cent. to ·50 per cent. silicon, and the details were fully given in the 'Report,' 1888, p. 69. The writer was asked by Mr. Turner and your Committee to investigate the effect of higher percentages of silicon.

The subject of alloys of iron and silicon has for some years occupied the writer's attention, but it is only lately that rich cast-iron alloys of silicon, *i.e.*, ferro-silicon, have been obtainable; and even now they cannot compare in richness of silicon with that of the manganese in ferro-manganese. The highest ferro-silicon yet made contains not more than about 18 per cent. to 20 per cent. of silicon. Fortunately, however, owing to the peculiar fact, noticed more fully further on, as to its lowness in carbon, this is much better fitted for experimental work as compared with, say, 20 per cent. ferro-manganese. Such percentage of silicon, though, comparatively speaking, not so high, is sufficient to enable a suitable experimental material to be made, *i.e.*, a resultant material not containing too much carbon to interfere with an examination of the effect of the metalloid silicon upon the metal iron. Thus, while in the case of rich spiegel or ferro-manganese the carbon present amounts to some 5 per cent. or 6 per cent., the 20 per cent. ferro-silicon, on the contrary, contains comparatively little carbon—always under $1\frac{1}{2}$ per cent., and often under $\frac{3}{4}$ per cent.; so that by means of this cast-iron alloy, when further diluted or mixed with pure iron, the malleable material or steel produced practically contains but little carbon. The curious fact that ferro-silicon alloys as they rise in silicon diminish in carbon was first noticed in some laboratory experiments eighteen years ago by Mr. Edward Riley; this will be again referred to further on. Whilst the scope of the experiments described in the present paper is in no way to deal with material other than malleable compounds of iron and silicon with small quantities of iron and manganese, it may be useful to give some general reference to previous experiments.

The only commercial employment of silicon with other metals is that of silicon bronzes. It is stated to act upon the copper in a similar manner to phosphorus. The qualities of such alloys are great strength and tenacity, high electrical conductivity, and resistance to corrosion. Wire made of this material is stated to have a conductivity of 80 per cent., and a tensile strength of about 36 tons per square inch.

Mr. Warren, in a recent number of the 'Chemical News,' states that silicon when in the nascent state converts platinum into a brittle silicide; or, by heating graphitoidal silicon in contact with platinum to a full red heat, combination at once takes place, resulting in a brittle regulus containing as high as 10 per cent. silicon, which is fusible at a red heat, and breaks with a crystalline fracture.

Silver and gold are reported as not presenting any great affinity towards silicon, but on heating a mixture of potassium silico-fluoride with either silver or gold in an amorphous condition to a high temperature, a well-fused regulus of silicide of the metal may be obtained. In the latter instance an alloy containing 5 per cent. of silicon is almost as brittle as antimony. Silver when alloyed with 10 per cent. of silicon is stated to have a slightly red tint.

Rich cast-iron alloys of silicon are now usually described respectively as ferro-silicon and silicon-spiegel, the latter containing manganese in addition to silicon. Silicious alloys of cast-iron were usually known as

glazed pigs, owing to their peculiar glazed appearance when fractured. It is curious that this very material—burnt pig, as it was often called, and only then made accidentally—was formerly thrown on one side as useless, whereas now it is made purposely on a commercial scale and in large quantities—another of the many proofs of the advantage of bringing scientific knowledge to bear upon industrial metallurgy. Such ferro-silicon in itself alone is perfectly useless in the refinery or puddling furnace or for iron castings. The early samples of silicious iron seldom contained more than from 4 per cent. to 6 per cent. of silicon; but Mr. Riley of London, in 1872, was the first to point out that rich ferro-silicon was likely to play an important part in metallurgical industry. By means of laboratory experiments he made in the crucible samples containing as high as 22 per cent. of silicon. He also discovered that as silicon increased carbon decreased, until with 20 per cent. of the former the latter was not present in quantities of more than $\frac{3}{4}$ per cent. to 1 per cent., and the greater part of this small amount existed as graphite. Spiegeleisen and ferro-manganese are the richest carbon alloys that can be produced, and they contain about 6 per cent. of carbon; ordinary cast-iron rarely exceeds more than about 4 per cent., and never more than about $4\frac{1}{2}$ per cent. So strong, however, is the action of silicon in preventing carburisation, even in the presence of a large excess of carbonaceous fuel, that in silicon-spiegel, an alloy of iron, manganese, silicon, and carbon, and notwithstanding the presence of a large amount of manganese, it—that is, the silicon—has still the upper hand, and prevents, as in the case of ferro-silicon, carburisation taking place. A few typical analyses of ferro-silicon, silicon-spiegel, ferro-manganese and spiegeleisen may be of interest here (*see* Table I.); for a fuller description, and for the methods of manufacture employed in their production, reference is given to Mr. Holgate's admirable paper on 'The Composition of Ferro-Manganese and Ferro-Silicon made in the Blast Furnace.' The writer is indebted to that paper for the analyses in question. Four of the samples quoted represent spiegel and ferro-manganese; and it is interesting to note that as the manganese rises there is a gradual increase of carbon up to as high as 7 per cent. A noteworthy fact is that if silicon, even in 50 per cent. ferro-manganese, is allowed to reach 4 per cent. the carbon is at once much reduced, in some cases to the low amount of about $2\frac{1}{2}$ per cent. This action is still more intensified in the alloys known as silicon-spiegel or silicide of manganese, of which two analyses are given. From the latter it will be seen that, provided the silicon exceeds 10 per cent., the carbon is reduced to an exceedingly low point, and that although manganese may be present even in comparatively high percentages this is quite immaterial. This decrease of carbon takes place both in the combined and graphitic form, but principally in the former. A very valuable property of these spiegel alloys is the fact that they contain practically no sulphur, the much-dreaded enemy of the steel-maker.

It will therefore be seen that in the blast-furnace, somewhat strange to say, silicon cannot be reduced without carbon is also present; yet when reduction of silicon occurs with the production of highly silicious iron, carbon is practically absent in the resultant material. The late Dr. Percy more than twenty years ago referred to this in his work 'Metallurgy,' and said that according to his experience no reduction can take place when silica and iron, without carbon, are heated together even at the highest furnace temperature. Possibly this might now be accomplished in

the powerful electric smelting-furnaces, and it would be interesting to know whether alloys as rich in silicon as are the present valuable alloys of ferro-manganese rich in manganese could be produced. If so, without doubt, considerable employment could be found for them in metallurgical industry.

TABLE I.—*Analyses of Spiegel, Ferro-Manganese, Silicon-Spiegel, and Ferro-Silicon.*

	Analysis per cent.				Remarks
	Carbon		Silicon	Manganese	
	Graphite	Combined			
Analyses of spiegel and ferro-manganese, showing the gradual increase of carbon as the manganese increases	—	4·27	·110	8·11	Sulphur and phosphorus practically absent, remainder being iron.
	—	4·78	·52	19·74	
	—	5·63	·42	41·82	
	—	6·53	·97	80·04	
	—	7·20	·14	80·04	
Analyses of special manganese, showing that if the silicon becomes high, the carbon diminishes very considerably	—	3·56	4·90	23·90	" "
	—	2·56	4·20	50·00	
Analyses of silicon-spiegel or silicide of manganese	·33	1·85	10·74	19·64	" "
	·67	·98	12·60	19·74	
	·90	·30	15·94	24·36	
Analyses of ferro-silicon	2·35	·05	8·77	2·42	" "
	1·85	·06	11·20	2·78	
	1·20	·23	14·00	1·95	
	·55	·11	17·80	1·07	

NOTE.—These analyses are from the paper of Mr. Holgate, Assoc.R.S.M. Darwen, on 'The Manufacture of Ferro-Manganese and Ferro-Silicon in the Blast-Furnace.'

Alloys or compounds of iron, carbon, and silicon, non-malleable in their nature, and coming under the term 'cast-iron,' have been thoroughly investigated in this country by Mr. T. Turner of Birmingham, the secretary of our B.A. Committee, and the results placed before the Iron and Steel Institute, so that it is unnecessary to do more than touch upon this matter here. Great credit is due to this investigator for the lengthy and valuable researches he has made in this direction ; as also to Mr. Keep of Detroit, U.S.A., who has lately presented interesting papers on the same subject to the American Institute of Mining Engineers. Mr. Keep sums up so well the general results of all investigations up to date, that it may be well to briefly mention them, especially as some of the remarks apply to a great extent to the malleable compounds or alloys of iron and silicon now being described. Both Mr. Keep and Mr. Turner find that white carbonaceous cast-iron, which would invariably give porous and brittle castings, are made free from honeycombs, and possess much greater strength by the addition of comparatively small amounts of silicon : the latter result as to gain in strength is one which was considered contrary to previous experience. If further additions are made, say up to 2 per cent., the iron becomes grey, and at this point the maximum strength is obtained. If more silicon is added, although the iron becomes still more

grey it also becomes weaker. By a still further addition a closer grain results, but it is even more brittle than in its white condition. Too much silicon also produces, as in the silicon steel now being described, lack of fluidity and greater shrinkage. Mr. Keep thinks that silicon in cast-iron is evidently, to some extent, combined with the iron and carbon; but whether it exists also in a form corresponding with graphitic carbon, mechanically mixed with the remaining mass, is a question still in dispute and unanswered. As now well known, the principal effect of silicon is to change the carbon from the combined to the graphitic state. One point particularly mentioned by Mr. Keep, and an important one, is that silicon irons have always had the reputation of imparting fluidity to other brands; and naturally this was at first supposed to be owing to the silicon added. It has now been found that this is not directly so, and that it is merely from the fact that the silicon present causes an increase in the quantity of

DIAGRAM 1.

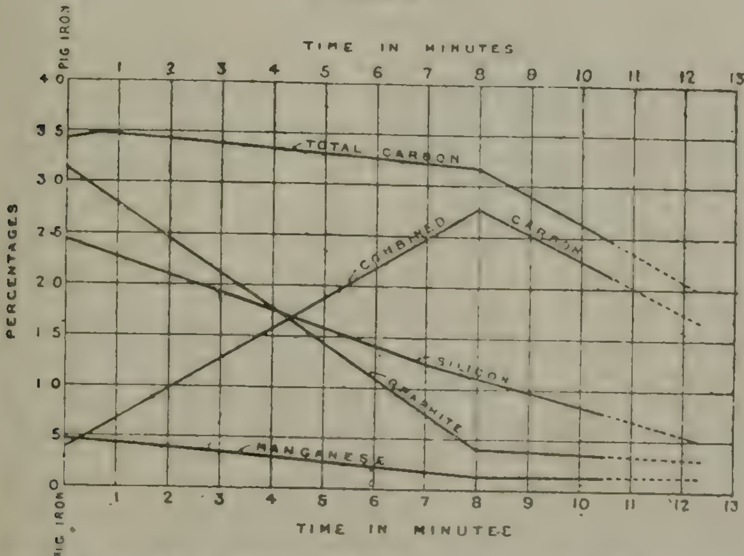


Diagram by Mr. King, showing the influence of Silicon during decarburisation upon the graphitic and combined carbon in cast-iron.

graphite, and consequently a more fluid cast-iron. It is not, therefore, directly the cause except by its indirect action on the carbon.

In conclusion on this point, Mr. Snelus said more than seventeen years ago, it is generally supposed that the absorption of much silicon tends to set free the carbon in the graphitic state. No statement more concisely expresses the influence of silicon on what is termed cast-iron than that given some eight years ago by Mr. C. F. King of Newport, U.S.A., in an able paper read before the American Institute of Mining Engineers on 'The Chemical Action of the Bessemer Process.' He said it is due to the presence of silicon in pig-iron that carbon is set free on cooling, and it is in proportion to the elimination of the silicon that the carbon remains chemically combined. Mr. King gives a diagram showing the rate of elimination of the metalloids in the process named, and it is a somewhat remarkable coincidence that the percentage point (1·8 per cent. silicon), where the diminishing silicon curve cuts the combined carbon and graphitic curves, is exactly that which gave the

maximum tensile strength in the material made by Mr. T. Turner, and later by Mr. Keep, in their numerous tests as to the effect of silicon upon cast-iron. The diagram referred to, and given above (Diagram 1), shows that by a diminution in the silicon highly graphitic pig-iron becomes rapidly mottled, and eventually white, although, practically, none or but little total carbon is oxidised, and this, as far as can be seen, solely by the fall of the silicon from 2·50 to 1·70 per cent. Whilst, therefore, Messrs. Turner and Keep show that white iron can be converted into mottled, and eventually grey, by means of additions of silicon, this diagram shows the converse, namely, that with silicon abstracted grey cast-iron becomes mottled and eventually white.

Outside, one might say even within, the laboratory, the properties of the metalloid silicon, or silicium, are but little known. No fuller details can be found than in that part of Dr. Percy's work 'Metallurgy' relating to silicon where all the methods for its production on a laboratory scale are given.

It is ordinarily described as a non-metal, very hard, dark brown in colour, a non-conductor of electricity, lustrous, not readily oxidised, and soluble in all ordinary acids with the exception of hydro-fluoric. It is said to resemble carbon in its general properties. Others add that it exists, like carbon, in a graphitic, amorphous, and combined or adamantine form; but this is still to be determined.

Mr. Henry J. Williams, St. Louis, Missouri (U.S.A.), this year presented a paper to the American Institute of Mining Engineers on 'The Determination of Silicon in Ferro-Silicons: its Occurrence in Aluminium as Graphitoidal Silicon, and a Study of its Reactions with Alkaline Carbonates.' As the latest investigation of this kind, it may be well to refer to the experiments. Mr. Williams's method of determining the metalloid was by means of fusion with sodium carbonate, the idea being to dissolve it as soluble sodium silicate, and leave the iron in a very spongy and finally divided condition so as to be readily attacked by acids. He noticed some curious facts during fusion. As soon as the sodium carbonate was thoroughly melted and the heat reached its maximum, the reaction became very violent, bubbles of gas (carbonic acid) rising to the surface and bursting into flame. This had been noticed before by another observer making experiments of similar nature with graphitic pig-iron. Mr. Williams was, however, somewhat puzzled, as the ferro-silicon with which he was experimenting was high in silicon and comparatively very low in carbon; yet it gave the same result. To ascertain why silicon acts exactly like carbon during the reduction, he endeavoured to obtain an iron entirely free from foreign elements, particularly carbon, but containing high silicon, but was unsuccessful. He found the desired condition realised in the aluminium of trade, most of which, in spite of its name, he states, contains not less than 3 per cent. or 4 per cent. of silicon, but of course no carbon. He found that a large part of the silicon in such aluminium seemed invariably present as an allotropic modification of that metalloid, crystallising in fine glistening black plates resembling some forms of graphite, and considered that this was evidently the graphitoidal form of silicon which Deville has mentioned in connection with aluminium, but which has not yet been isolated or found to exist in iron. Dr. Percy mentioned at length the same fact, and describes the material as resembling graphite from iron smelting-furnaces, and as being hard enough to scratch glass, with a specific gravity of 2·49. As regards, however, the

form silicon may take in cast-iron or steel, Mr. Keep considers that whether it exists in a state corresponding to graphitic carbon, and mechanically mixed with the remaining mass, is still a question in dispute. Mr. Holgate of Darwen, also, in the paper before referred to, after making many analyses, says he has never found any evidence as to the existence of graphitic silicon in such alloys, though he has noticed some slight difference in the behaviour of silicon when dissolved in acids. Mr. Turner in his paper some two years ago, after carefully investigating this point both by means of experiments of his own and those of Sir Frederick Abel, Mr. Snelus, and others, says that it may at any rate be considered, in a vast majority of cases at least, that silicon has only one form. Finally, therefore, the practical metallurgist has at present, apparently, no means of readily determining this point, although he may have reason to think that silicon does vary its form in either cast-iron or steel.

In metallurgical literature but little information is to be found as to the effect of silicon upon iron. Mr. Howe in his excellent work on 'The Metallurgy of Steel' gives an excellent *résumé* of what has appeared. Some fourteen years ago in America good results were promised by a process, which was to use 'codorus or silicon ore,' as it was termed. This was to dephosphorise or neutralise the phosphorus in the metal under treatment. Only a few years back the writer had reason to investigate this matter in America, but found that this so-called puddled silicon iron or silicon steel contained no silicon. The whole matter was well summarised by the well-known metallurgist, Holley, of America, who said, or rather sang, of it :—

> There was an old man of Codorus
> Who said he took out the phosphorus
> So the iron he puddled and with chemicals muddled,
> But the puddling took out the phosphorus.

Referring now to the consideration of silicon alloyed with the metal iron, the common belief has been that steel which has to be used in its forged state should contain practically none or as small an amount as possible. Any quantity exceeding ·10 per cent., or up to ·20 per cent. at most, has been considered to be highly injurious. 'Give a dog a bad name' is well illustrated in the present case, as will be seen from the results and tests given. At any rate it may be safely said that silicon has been blamed in a somewhat hasty manner. This blame may be well deserved in alloys of carbon, silicon, and iron, as such alloys as regards ductility have, no doubt, proved unreliable and of little value; but the blame was put at the door of silicon, whereas it is now proved that silicon alloyed with iron, provided carbon is absent, or only present in small amounts, gives good tests as to toughness and malleability. It will be seen that 1½ or even 2 per cent. may be present and yet the material possess 25 to 30 per cent. elongation; whereas the same percentage of carbon alloyed with iron would give a product barely malleable, and one possessing practically no properties of elongation under tensile stress Whilst therefore the common belief that alloys of carbon, silicon, and iron are brittle, or even dangerous, is quite correct, the cause is not due to silicon only, but to the combination of silicon with carbon and iron—a case parallel, to some extent, to that pointed out by the well-known Terre Noire Company's experiments, where it was proved that phosphorus may be present in iron provided the carbon is low and the manganese high; a fact—that is, as regards phosphorus—still more prominent in wrought irons.

As also pointed out by Mr. Howe, 'Silica is often mistaken for silicon: who knows how far it is responsible for this metalloid's bad name?' This was actually noticed by Mr. Turner in test bars of steel containing comparatively low percentages of silicon—that is, under ·5 per cent.—much of the silicon present being in the oxidised condition.

Also, according to M. Gautier, there is a difference between steel made with silicon only and that with silicon and manganese, *i.e.*, between a product made by adding ferro-silicon (carbon, silicon, and iron alloy), and that with silicon-spiegel (carbon, silicon, manganese, and iron alloy); and he mentions the following interesting experiment by his then colleague, M. Pourcel.

In a porcelain tube were placed two receptacles, one holding steel made by adding ferro-silicon only, and the other steel by an alloy of silicon-spiegel. A current of chlorine was passed until all the iron was removed in the state of chloride. It was then seen that in the first receptacle there remained a network of silicate of iron preserving the original formation of the piece, whilst steel by silicon and manganese alloy left no residuum. Also, that such steel with no manganese was red-short, lacked fluidity, and possessed other defects. The writer has, however, not noticed such difference in the material now described, which in its molten state pours well, the ingots forging easily, and up to 2 per cent. silicon the ductility in the testing-machine being very good.

However, as suggested by Mr. Howe, possibly silicon does enter into different combinations in steel, some promoting, some impairing ductility and malleability. In favour of this is the fact that so many well-known scientists and metallurgists have utterly condemned in forged steel the employment of silicon, even if present in small amounts. Such strong opinions would not be expressed without good grounds, and a reasonable explanation for the apparent discrepancy noticed by different observers seems to some extent to be in the direction named. At any rate the samples described in this paper, and containing up to 2 per cent., present a remarkable ductility and toughness both in the bending and tensile specimens.

The writer wishes it to be understood that he does not claim that silicon should take the place of carbon. Smaller quantities of carbon produce the requisite hardness and different tempers required in the industrial application of steel, and in fact silicon alone does not produce a steel that will harden by water-quenching, thus in this respect resembling manganese steel. Still it is a somewhat remarkable fact that a steel (specimen C) containing 1·60 per cent. of a metalloid ordinarily so much distrusted stretched 35·10 per cent. (on 2″), with 54·52 per cent. reduction in area, and a test bar from the same material tested by Professor Kennedy gave 24·30 per cent. (on 10″), with 58·30 per cent. reduction in area. Also, had not the specimen D, tested by Professor Kennedy, broken in the threads (the diameter of the bar over the threads being only ·93 against ·898 of the tested part of the bar: too small a difference with hard steel in the holding part), no doubt his test would have confirmed the writer's that a material with even 2·13 per cent. of silicon will elongate 36·50 per cent. on 2″ (equivalent to about 27 per cent. on 10″), with 59·96 per cent. reduction in area. So that whilst it may not be advisable to use silicon as a hardener in making steel, it is important to have it proved that the brittleness noticed in ordinary so-called silicon steel is

NOTES.

1. The tests by Professor Kennedy were made with a lever machine; those by the author with a hydraulic machine made by Sir Joseph Whitworth.

2. Unfortunately, the tests made by Professor Kennedy were made on bars with holding parts only ·03″ larger than that under stress. The bars were thus much more liable to break in the thread. In two specimens this occurred, and the result of these two tests can hardly be considered complete.

3. In the Whitworth machine 'permanent set' is usually readily observed by the 'give' of the finger on dial; but to be quite sure on this point, the test-pieces were taken out and very carefully gauged in a Whitworth measuring machine at successive and increasing stresses, until the permanent set was discovered by an actual increase in the length of the test-bar.

4. The relative hardness of other substances determined by Mr. Turner's sclerometer:—

Lead	1
Copper	8
Softest iron	15
Mild steel	21
Good cast-iron	21 to 24
Hard cast-iron (scrap)	36
Window glass	60
Very hard white iron	72
Manganese steel	Under test
Silicon steel	20 to 36

5. These tests will be found plotted on Diagram 3.

TABLE II.—*Tensile and Bending Tests of Forged Silicon Steel containing from ·24 per cent. to 8·83 per cent. Silicon.*

[*To face p.* 274.

	Analysis per cent.						[illegible]	How [illegible]	Whether [illegible] Condition	Machine [illegible]	Original Diameter, (inches)	Original Area, (sq. ins.)	Limit of [illegible] tons per square inch	Amount of Stretch at Limit	Breaking Load in tons per square inch of Original Area	Ratio of Limit to Break	Extension measured on a Length of — inches	Total Extension per cent.	Reduction of Area per cent.	Appearance of Fracture of Test bar	Appearance of Fracture of Annealed Forged Bar from which Test bar was prepared	Modulus of Elasticity by [illegible] in lbs. per square inch	Bending Test of Annealed Bars, ½" wide by ¼" thick: Tests by Hadfield	Tests by Turner	Hardness [illegible] by Mr. Turner	Remarks
		[illegible]	[illegible]	[illegible]	Phos.	Man-ganese																				
A	—	·14	·24	·08	·05	·14	Ingot	Fairly well	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Samples A to D bent double cold, [illegible] soft steel, and afterwards [illegible] without cracking.
A				—			Test-bar		Unannealed	Hadfield	·7979	·5	22·00	·0065	33·00		2	30·07	54·71	Silky	—	—	—	—	—	
A					—	—	,,		Annealed	,,	·7979	·5	15·17	[illegible]	25·50	—	2	37·55	60·71	Silky	Mild and rather burnt	—	Bent double cold	Bent cold through 180°, radius ⅜"; perfect	20	
A	—	—	—	—	—	—	—	—	,,	Kennedy	·898	·633	15·17	—	23·44	·647	10	16·9	42·7	Silky, but with a large reedy flaw	—	30,160,000	—	—	—	This test-bar had a black oxidised surface at fracture quite unwelded.
B	—	·18	·70	—	—	·21	Ingot	Very well	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
B	2	—	·70	—	—	—	Test-bar	—	Unannealed	Hadfield	·7979	·5	25·00	·013	34·00	—	2	29·50	54·54	Silky	—	—	—	—	—	
B					—		,,		Annealed	,,	·7979	·5	19·00	·0015	[illegible]	—	2	34·02	[illegible]	Silky	Mild, close, granular		Bent double cold	Bent cold through 180°, radius ⅜"; perfect	20	
B	—	—	·87	—	—	—	—	—	,,	,,	·7979	·5	19·00	—	28·50	—	2	25·45	42·56	Silky	—	—	—	—	—	
B				—	—	—		—		Kennedy	·898	·633	18·16	—	27·49	·631	10	26·5	66·4	Silky at edges, very finely granular at centre	—	29,970,000	—	—	—	
C	—	·19	1·60	—	—	·23	Ingot	Very well	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
C	3	—	1·60	—	—	—	Test-bar	—	Unannealed	Hadfield	·7979	·5	28·0	·008	37·5	—	2	31·10	50·58	Centre silky, outside finely crystalline	—	—	—	—	—	
C	[illegible]		[illegible]		—		,,	—	Annealed	,,	·7979	·5	27·0	·0015	33·00		2	35·10	[illegible]	Silky	Mild, close, granular	—	Bent double cold	Bent cold through 180°, radius ⅜"; perfect	21	
C			—	—	—	—		—		Kennedy	·898	·633	[illegible]		[illegible]	[illegible]	10	[illegible]	[illegible]	Silky at edges, very finely granular at centre	—	29,600,000	—	—	—	
D	—	[illegible]	[illegible]	[illegible]	[illegible]	·25	Ingot	Very well	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
D	4	—	2·11	—	—	—	Test-bar	—	Unannealed	Hadfield	·7979	·5	31·00	·004	39·5	—	2	18·48	28·02	Silky	—	—	—	—	—	
D						—	,,	—	Annealed	,,	·7979	·5	[illegible]	[illegible]	[illegible]		2	[illegible]	[illegible]	Silky	Granular, but crystals much larger	—	Bent double cold	Bent cold through 180°, radius ⅜"; perfect	24	
D	—	—	—	—	—	—	—	—	—	Kennedy	·898	·633	20·22	—	27·98	·723	10	5·6	—	Broke in screw thread (·93" diameter); fracture somewhat coarsely crystalline	—	26,200,000	—	—	—	
E	—	·20	2·67	—	—	·25	Ingot	Very well	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
E	[illegible]	—	[illegible]		—		Test-bar	—	Unannealed	Hadfield	·7979	·5	32·0	·0065	42·5	-	2	17·6	21·36	Coarse and slightly granular	—	—	—	—	—	
E	[illegible]		[illegible]		—	—	,,	—	Annealed	,,	·7979	·5	24·0	·0052	32·0	-	2	[illegible]	6·64	Coarse and granular	Coarse, open	—	Bent double, but broke in radius with last blow	Bent through 180°, but broke off sharp at bend	26	
E	—	—	—	—	—	—	—	—	—	Kennedy	·898	·633	23·5	—	28·52	·824	10	2·5	—	Broke in screw thread (·93" diameter); fracture somewhat coarsely crystalline	—	28,500,000	—	—	—	
F	—	·21	3·46	—	—	·29	Ingot	Very well	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
F	6	—	3·39	—	—	—	Test-bar	—	Unannealed	Hadfield	·7979	·5	35·0	·01	47·5	—	2	11·10	14·22	Coarse and slightly granular	—	—	—	—	—	
F	[illegible]	—		—	—		,,		Annealed	,,	·7979	·5	30·0	·009	39·0	-	2	8·85	9·28	Coarse and granular	Coarse, open	—	Bent only to right angle; much stiffer	Broke at 45°	30	
F	—	—	—	—	—	—	—	—	—	Kennedy	·803	·506	29·45	—	34·17	·862	10	3·2	5·65	Entirely and somewhat coarsely crystalline	—	28,410,000	—	—	—	
G	—	·25	4·49	—	—	·36	Ingot	Very well	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
G	7	—	4·18	—	—	—	Test-bar	—	Unannealed	Hadfield	·7979	·5	45·0	·003	49·0	—	2	·004	·20	Coarse and slightly granular	—	—	—	—	—	
G	[illegible]		[illegible]				,,		Annealed	,,	·7979	·5	None visible		38·0		2	·64	·98	Coarse and granular	Coarse, open	—	Very brittle; would not bend at all	Broke at 15°	33	[illegible] was not quite straight and snapped across the middle with a blow from a hammer while being 'set' by the workman. It was evidently very brittle.
G	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
H	—	·26	5·53	·06	·04	·29	Ingot	Very well	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
H	8	—	4·9	—	—	—	Test-bar	—	Unannealed	Hadfield	·7979	·5	None visible	—	48·0	—	2	·30	·70	Coarse and slightly granular	—	—	—	—	—	
H	16	—	4·80	—	—	—	,,	—	Annealed	,,	·7979	·5	25·0	·0075	25·0	—	2	·37	Broke in thread	Broke in thread; coarse and granular	Very coarse	—	Very brittle; would not bend at all	Snapped in three pieces at first blow of hammer	36	Test-bar broke simultaneously in two places, so that a piece 5" long from middle flew right out. This piece itself was nearly separated in two parts by a crack.
H	—	—	—	—	—	—	—	—	—	Kennedy	·803	·506	None visible	—	38·98	—	10	·7	1·98	Entirely and somewhat coarsely crystalline	—	28,650,000	—	—	—	
I	—	[illegible]	7·23	—	—	·29	Ingot	—	—	—	—	No test bar made; would not forge				—	—	—	—	—	—	—	—	—	—	
I	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	,,	—	—	—	—	No test bar made; would not forge				—	—	—	—	—	—	—	—	—	—	

NOTES

1. [illegible] by the author with a hydraulic machine made by Sir Joseph Whitworth.

2. [illegible] Professor Kennedy were made on bars with holding parts only ·03" larger than that under stress. The bars were thus much more liable to break in the thread. In two specimens this occurred, and the result of these two tests can hardly be considered complete.

3. [illegible] by the 'give' of the finger on dial; but to be quite sure on this point, the test pieces were taken out and very carefully [illegible] in a Whitworth measuring machine at successive and increasing stresses, until the permanent set was discovered [illegible] in the length of the test bar.

4. The relative hardness [illegible] determined by Mr. Turner's sclerometer:—

Lead	1
Copper	[illegible]
Softest iron	[illegible]
Mild steel	[illegible]
Good cast iron	[illegible] to 24
Hard [illegible]	[illegible]
Window glass	[illegible]
Very hard white iron	72
Manganese steel	Under test
Silicon steel	20 to 36

5. These tests will be found plotted on Diagram 3.

due rather to the combined presence of the two hardeners, silicon and carbon. It may be here mentioned that the ductility noticed cannot be attributed to manganese, which was only present in small quantities, about ·20 to ·30 per cent.

The material employed in these experiments was made by melting in crucibles good wrought-iron scrap low in sulphur and phosphorus, to which was added in varying and increasing quantities a rich ferro-silicon containing 20 per cent. of silicon. The ingots, $2\frac{1}{2}''$ square, were reduced by forging in the ordinary method to $1\frac{3}{4}''$ square billets, then rolled down to bars $1\frac{1}{8}''$ diameter.

The effect of silicon upon iron is as follows, (1), in its forged condition; (2), in its cast condition:—

1. *Forged Condition.*—The forge reports that the material A (·24 per cent. Si) did not forge well, cracking somewhat whilst being hammered, but all the other samples B to H (·79 per cent. to 5·53 per cent. Si) when forged at a fair yellow heat required no special care; thus clearly showing that silicon even up to as high as about 6 per cent. does not destroy the malleability of the metal iron. Upon, however, exceeding this percentage the material is red-short, crumbles at a low heat, and notwithstanding the low percentage of carbon present (·25 per cent.), becomes really a species of cast-iron. It should also be here mentioned that if the carbon had been higher the point at which malleability ceases would have been with a much lower percentage of silicon.

Nor is such red-shortness removed by the addition of manganese.

It may also be here mentioned that no return of strength takes place by a further addition of silicon, as is so specially characteristic of manganese steel. Any further addition merely increases its resemblance to silicious cast-iron. Nor do gradually increasing percentages, as is the case with manganese steel, destroy the magnetic properties of the alloy; a 7 per cent. material seems quite as susceptible as ordinary iron drillings.

As regards the results of the mechanical tests on this steel in its forged state, these are so fully detailed in Table II. (Tensile and Bending Tests), Table III. (Compression Tests), and Diagram 3, that it is only necessary to add a few remarks here.

Apparently silicon up to $1\frac{1}{2}$ or $1\frac{3}{4}$ per cent. added to iron, although increasing the limit of elasticity and raising the tensile strength, does not impair ductility, but after this the further increase of tensile strength noticed is only obtained with a serious loss of ductility. Apparently there is no sharp line of demarcation. After passing $1\frac{1}{2}$ per cent. further slight increases cause great changes in the characteristics of the material. In this respect, therefore, its action rather resembles that of carbon in contradistinction to the action of manganese, of which much larger amounts are required to effect similar changes.

The fractures from the tensile test-bars up to 'D' specimen (2·18 per cent. Si) are silky, after this completely and coarsely crystalline. As in the specimens in the cast state, neither annealing nor water-quenching seem to have any effect on the structure.

The annealed flat bending pieces, $\frac{1}{2}''$ wide by $\frac{1}{4}''$ thick, gave good results, specimens A, B, C, and D (·24 per cent. to 2·18 per cent. Si) bending double cold without fracture, more like dead soft steel, and after being bent double the pieces were flattened close together cold without showing signs of fracture. Specimen E (2·67 per cent. Si)

T 2

also bent double cold, but broke in the radius with the least blow. F (3·46 per cent. Si) was much stiffer, and bent only to a right angle. G and H (4·49 per cent. and 5·53 per cent.) would not bend at all, and were exceedingly brittle. These bending tests were confirmed by Mr. Turner's experiments with bars of the same size; up to D specimen the samples bent to an angle of 180° with $\frac{1}{8}''$ radius.

Pieces from the bars used for bending tests were also tested for weldability, but entirely without success. The writer's experience has always been that silicon is quite fatal to welding, notwithstanding that the contrary might be expected from the fact that silica is of such material assistance in welding wrought iron.

As regards water-quenching or hardening, samples A, B, C, and D (·24 per cent. to 2·18 per cent. Si) were unaffected by even the highest heat. Even if plunged at welding heat into water made specially cold no hardening beyond a surface stiffening took place, nor did their toughness seem impaired by this treatment. Specimen E (2·67 per cent. Si) was heated to an ordinary yellow heat and plunged into cold water at about 70° F. This piece was much stiffened, but only broke on being bent double. Another piece of the same material heated to a welding heat, and plunged into water at about 52°, also proved very stiff, and only broke when bent double; F (3·46 per cent. Si): this sample was only stiffened by being water-quenched at a welding heat. It was just as brittle as before, and had not hardened, being easily touched by a file. In this respect, therefore, *i.e.* as to being toughened by water-quenching, this material differs from manganese steel. The heating did not cause much alteration in fracture, the crystallisation being still open and coarse. H (5·53 per cent.) was quenched both at ordinary heat and at a welding heat, and although the surface was skin-hardened, upon being fractured it was easily filed. These tests, therefore, clearly prove that silicon does not confer the same property as carbon does upon iron, *i.e.* of becoming hardened when dipped hot into a cooling medium. It should also be here stated that the whole of the samples were subjected to high heats, even to a welding temperature, without falling to pieces; in fact, as regards this point they behaved more like mild steel; apparently proving that silicon itself does not cause iron to become red-short.

That silicon steel has a certain kind or degree of softness or lack of body compared with carbon steel is especially brought out in the compression tests (Table III.), where sample E, although apparently very hard and brittle (high in the scale of Turner's hardness tests, viz. 33), crushed up 38 per cent. of its length under a compression load of 100 tons per square inch. A correspondingly hard temper of carbon or tungsten steel would not shorten more than 20 per cent., or, if hardened, would remain unaltered. A very mild steel, containing not more than ·20 per cent. of carbon, would not shorten much more than this sample, containing over $2\frac{1}{2}$ per cent. of silicon. At any rate, therefore, silicon is not so powerful a hardener of iron as is carbon. Mr. T. Turner has tested this material in his sclerometer, or hardness-testing machine, the results of which are given under this head in Table I.

In order to test this steel in the shape of wire, samples E (2·67 per cent. Si) and G (4·49 per cent. Si) were reduced to rods, and Messrs. Shipman & Co. of Sheffield kindly undertook to draw them into wire. The G material, though readily rolled into rods, would not, however, draw, nor did annealing soften or give it the requisite ductility. In the

TABLE III.—*Compression Tests of Forged Silicon Steel.*

Series	Test-bar Mark	Analysis per cent.			Load applied in tons per square inch	Reduction in Length produced by Load	Diameter Increased to
		Carbon	Silicon	Manganese			
B	205	·18	·79	·21	—	Before being Tested 1·0	·7977
No. 205 gave a sharp indication at 32 tons.					10	·9958	·799
					20	·9915	·800
					30	·9472	·822
					40	·853	·8895
					50	·814	·894
					60	·7305	·95
					70	·658	1·002
					80	·5975	1·056
					90	·547	1·115
					100	·503	1·153

Series	Test-bar Mark	Analysis per cent.			Load applied in tons per square inch	Reduction in Length produced by Load	Diameter Increased to
		Carbon	Silicon	Manganese			
E	206	·20	2·67	·25	—	Before being Tested 1·009	·7979
No. 206 gave no indication of set by pointer.					10	1·009	·7979
					20	1·008	·8000
					30	·9915	·808
					50	·901	·850
					100	·622	1·0345

Series	Test-bar Mark	Analysis per cent.			Load applied in tons per square inch	Reduction in Length produced by Load	Diameter Increased to
		Carbon	Silicon	Manganese			
F	207	·21	3·46	·29	—	Before being Tested 1·009	·7985
No. 207. No indication of set by pointer.					10	1·009	·7985
					20	1·009	·795
					30	1·0045	·8000
					100	·6455	1·0115

Series	Test-bar Mark	Analysis per cent.			Load applied in tons per square inch	Reduction in Length produced by Load	Diameter Increased to
		Carbon	Silicon	Manganese			
G	208	·25	4·49	·36	—	Before being Tested 1·008	·7985
No. 208. No indication of set by pointer. Gave several loud reports as pressure was increased up to 50 tons, and then ceased.					10	1·008	·7985
					20	1·008	·7985
					30	1·0045	·8000
					40	·9895	·806
					100	·683	1·003

rod state the tensile strength was 59 tons per square inch, with 12 torsions in 8″. Crucible carbon steel would stand about the same test, and Swedish Bessemer with high carbon slightly higher in torsion, but lower in tensile strength.

The material E was readily drawn to No. 20 B.W.G., standing 180 lbs. tensile strength (64 tons per square inch), with 157 torsions in 8″. Annealing lowered the tensile strength to 120 lbs. (about 48 tons per square inch), and slightly increased the torsions to 169 in 8″. The wire-makers endeavoured to harden both G rods and E wire both in oil and water, but without success.

Professor Barrett, of Dublin, has kindly undertaken to determine the electrical properties of the steel wire just mentioned, but the results are not yet completed. About twelve months ago the writer, thinking that silicon might confer upon iron qualities suitable for the manufacture of magnets, sent to Mr. Bottomley, in Sir W. Thomson's laboratory, Glasgow, a forged sample, containing 4·43 per cent. of silicon and ·18 per cent. of carbon.

DIAGRAM 2.

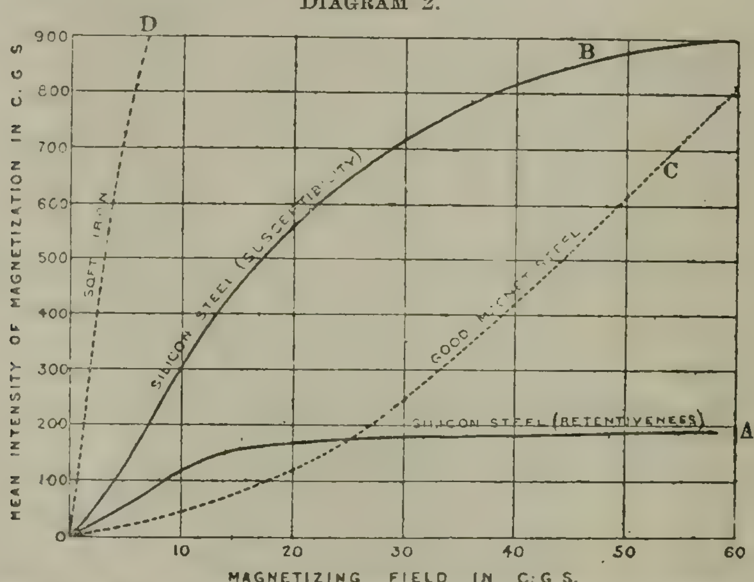


Diagram by Mr. Bottomley, showing magnetic retentiveness and susceptibility of Silicon Steel [4·43 per cent. Si] as compared with ordinary iron and steel.

The results of Mr. Bottomley's experiments, as will be seen from Diagram No. 2, were unfavourable. He found that the material had less susceptibility and more retentiveness than good soft iron, and that it had enormously less retentiveness than hard steel suitable for magnet-making. The diagram shows two curves, 'A' and 'B'; 'A' showing the retentiveness of the bar, and 'B' the susceptibility. The dotted curve 'C' represents what the bar should be if it were suitable for magnet-making, and the dotted curve 'D' what it would be were it good soft iron.

Considerable attention having been given to the curious non-magnetic properties of manganese steel, the writer was led to make the approximate tests detailed in Table IV., to see if iron alloyed with other elements than manganese would also lose its magnetic susceptibility. From the list given it will be seen that, practically, manganese is the only exception; for

TABLE IV.—*Table of Ferro-alloys, showing their Magnetic Susceptibility.*

Name of Alloy	Special Constituent	Composition % (in some cases approximate)									Magnetic susceptibility	
		C %	Si %	S %	P %	Mn %	Cr %	W %	Al %	Fe %	In bulk	In drillings or powdered slate
Spiegeleisen	Manganese	4¾	—	—	—	14	—	—	—	81¼	Attracted	—
"	"	5½	—	—	—	36	—	—	—	58½	Not attracted	Very slightly influenced
Ferro-manganese	"	7	—	—	—	82	—	—	—	11	" "	Very slightly influenced
Ferro-silicon	Silicon	1	16	—	—	1	—	—	—	82	Strongly attracted	—
" "	"	¾	20	—	—	2	—	—	—	77¼	" "	—
Silicon-spiegel	Manganese and silicon	2	8	—	—	20	—	—	—	70	Easily attracted	—
" "	Manganese and silicon	1½	16	—	—	20	—	—	—	62½	Strongly attracted	—
Ferro-chrome	Chromium	4	1	—	—	1	8	—	—	86	" "	—
" "	"	5	2	—	—	1	28	—	—	64	" "	—
" "	"	5	1	—	—	1	63	—	—	30	Not attracted in the slightest	Very slightly influenced
" "	"	5	2	—	—	1	79	—	—	13	Not attracted	—
Ferro-aluminium	Aluminium	1	1½	—	—	—	—	—	10	87½	Strongly attracted	—
" "	"	3	1½	—	—	—	—	—	12	83½	Very strongly attracted	—
" "	"	3	1½	—	—	—	—	—	18	77½	Very strongly attracted	—
" "	"	1	1½	—	—	—	—	—	20	77½	Slightly attracted	Strongly attracted
Ferro-tungsten	Tungsten	4	1	—	—	1	—	40	—	54	Very strongly attracted	—
Ferro-phosphorus	Phosphorus	1	⅓	—	10	4	—	—	—	84⅓	Strongly attracted	—
Ferro-sulphur	Sulphur	½	¾	5	—	—	—	—	—	93¾	" "	Strongly attracted

as regards ferro-chrome, it is only when very high percentages of chromium are reached that the material is not susceptible.

Malleable ferro-alloys.—Malleable compounds of iron with other elements so far experimented upon (including carbon, silicon, sulphur, phosphorus, chromium, tungsten, aluminium, and nickel) are strongly susceptible to magnetisation.

Alloys of manganese and iron, however, form an exception to this. As is now well known in manganese steel, as soon as the manganese exceeds 8 or 9 per cent. the material is only attracted when in a finely divided state, such as drillings or powder, and with further increase of manganese even this slight susceptibility disappears. The same fact is noticed as regards the non-malleable compounds of iron and manganese. Alloys of iron, nickel, and manganese are also not susceptible.

2. *Cast State.*—As might be expected, the whole of the samples are very free from honeycombs; but this soundness in the cast state is only acquired at the expense of toughness or ductility. As regards this freedom from honeycombs, it may be of interest to state here that although silicon does produce soundness in steel, yet Mr. Holgate noticed that in making ferro-silicon of 13 to 15 per cent. there is in casting an unusually large outburst of gas, and the pigs are exceedingly full of honeycombs. A sample is exhibited among the specimens accompanying this paper. In watching a cast of material of this percentage from the blast-furnace he noticed that when the exterior of the pigs became almost solid, and whilst the interior was still liquid, the metal began to boil up, and frequently for fifteen or twenty minutes some cwts. of metal in each bed boiled over, this going on until the pigs were quite set and solid.

It would be interesting to know what is the cause of this outburst, and the composition of the escaping gases. It has been stated in metallurgical literature that in some hot overblown Bessemer charges silicon may be present in considerable percentages and yet the steel rise or boil over when poured into ingot-moulds.

Silicon steel pipes or settles to a much greater extent than ordinary steel, and this in itself is a considerable disadvantage. Its fluidity when being poured is less than that of ordinary steel. The crystallisation or form of fracture of the lower percentages is somewhat like ordinary mild cast steel, but on exceeding about $2\frac{1}{2}$ per cent. Si, a striking change occurs: the crystals become very large, glazed in appearance, and cleave somewhat after the nature of a spiegeleisen. As this large and marked crystallisation increases the material becomes exceedingly brittle, and if still further additions are made the appearance of the material approaches silicon pig-iron, and is non-malleable.

High percentages of silicon in the cast or unforged material cause a considerable increase in shrinkage or contraction. This point is already a difficult one with the steel founder, who for many years has been on the horns of the dilemma that whilst silicon increases soundness it increases the tendency of castings to draw. In cast-iron this fact of silicon also increasing contraction has been noticed by Mr. Keep.

Also as in the forged, so in the cast material, when the Si exceeds about 2 per cent., and the peculiar crystallisation noticed in the samples exhibited commences, neither annealing nor water-quenching seems to have any effect in changing the structure.

It is well known that considerable difficulty is experienced in dis-

solving drillings of ferro-silicon ; so tedious is the process that recourse is usually made to the sodium carbonate process. This is not requisite with silicon steel, which requires only the ordinary hydrochloric-acid method. The silica residue is very clean and free from iron.

A considerable number of estimations have proved that the silicon is very uniform and homogeneous in this steel. Analyses taken from different parts of the same ingot and bar give results very similar to each other. No traces of graphite are noticed, the carbon always being present in the combined form. If the material analysed is in the form of drillings they keep their shape, the iron being dissolved out.

Experiments have been made with this steel in comparison with other material as regards its corrosion. The following table gives the time of immersion in the sulphuric acid, and the loss :—

TABLE V.—*Table of Corrosion Experiments.*

—	—	Percentage of Silicon	Strength of Acid H_2So_4	Length of Immersion	Loss %	Colour after Treatment	Remarks
Silicon Steel (C) .	Bar	1·60	50 %	21 days	6·32	Very bright . .	After being taken out of the acid and dried the silicon steel and wrought iron appeared as if burnished, and retained their brilliancy for some time.
„ „ (E) .	„	2·67	„	„	3·32	„ „ . .	
„ „ (G) .	„	4·49	„	„	4·29	Very bright. Soon dulled over although carefully covered up	
Ordinary mild steel	„	—	„	„	7·48	Dull bright . .	
Wrought iron .	„	—	„	„	4·47	Most brilliant .	
Silicon steel (E) .	Wire 20 B.W.G.	2·67	„	„	31·80	Very bright . .	
Ordinary mild steel	„	—	„	„	17·29	Dull	
Ordinary wrought iron	„	—	„	„	17·09	Very bright, like wrought bar	
Manganese steel .	„	Mn. 12%	„	„	51·18	—	

Moisture Test.

—	—	Percentage of Silicon	Weight before placing in Moist Atmosphere	Weight after keeping 21 days in Moist Atmosphere	Increased in Weight
Silicon steel (C) .	Bar	1·60	20·634 grams.	20·644 grams.	·01 gram.

The following table gives the specific gravities of the silicon steel ; also ferro-silicon :—

TABLE VI.—*Specific Gravities.*

—	—	Percentage of Silicon	Specific Gravity	Remarks
Silicon steel (E) . .	Ingot	2·67	7·38	—
„ „ „ . .	Wire 20 B.W.G.	2·67	7·88	—
„ „ (G) . .	Ingot	4·49	7·54	—
Ferro-silicon . .	—	5·00	7·00	—
„ „ . .	—	8·00	6·943	—
„ „ . .	—	16·00	5·303	Doubtful
Ordinary grey cast-iron	—	—	7·10	—

TABLE VII.—*List of Samples exhibited to illustrate this Paper.*

SECTION I. Samples of silicon steel in the cast state containing from ·24 to 8·83 per cent. of silicon.

SECTION II. Samples of silicon steel in the forged state containing from ·24 to 5·53 per cent. of silicon.

SECTION III. Test-bars as mentioned in Table II.

SECTION IV. Bending pieces given in Table II.

SECTION V. Compression pieces given in Table III.

SECTION VI. Samples of ferro-alloys to illustrate magnetic properties.

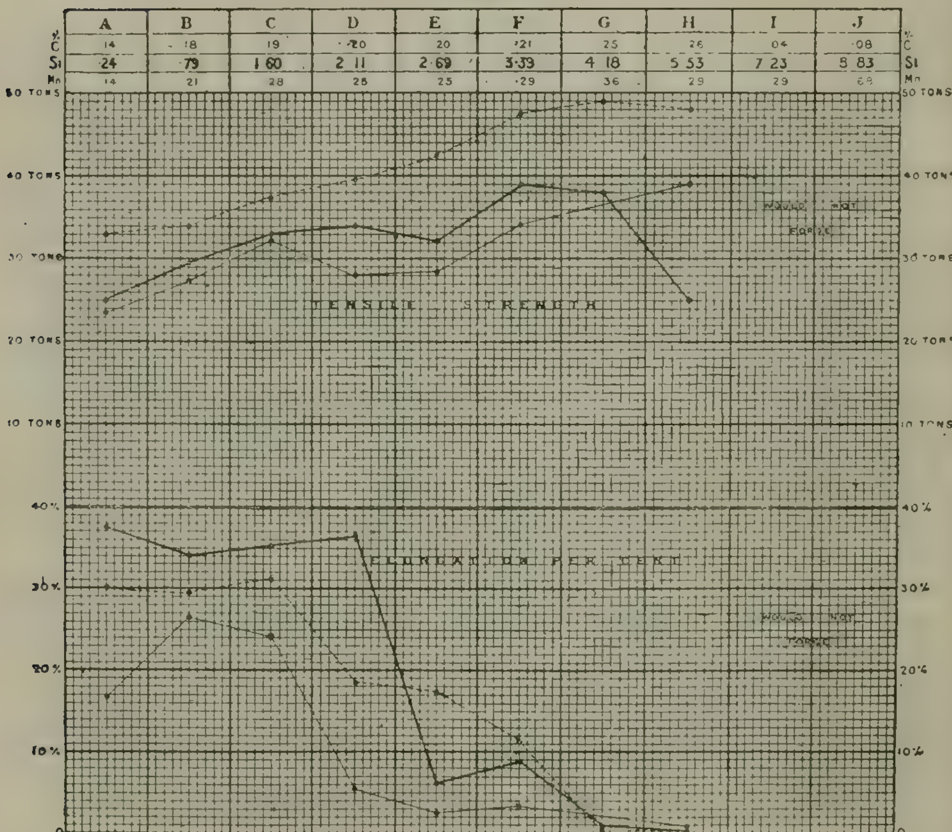
SECTION VII. Silicon steel wire 2·67 per cent. Si, 20 B.W.G.

Sample of ferro-silicon containing 16 per cent. silicon, yet honeycombed.

Silica from silicon steel.

Also other samples.

DIAGRAM 3.



Tensile and elongation tests of Silicon Steel, plotted from Table I.

——— = Annealed test-bars (Hadfield) on 2″ lengths.
- - - - - = Unannealed „ „ „ 2″ „
——— = Annealed „ (Kennedy) „ 10″ „

Report of the Committee, consisting of Mr. H. Bauerman, Mr. F. W. Rudler, Mr. J. J. H. Teall, *and* Dr. H. J. Johnston-Lavis, *appointed for the investigation of the Volcanic Phenomena of Vesuvius and its neighbourhood.* (*Drawn up by* Dr. H. J. Johnston-Lavis, *F.G.S., Secretary.*)

Geological Map of Vesuvius and Monte Somma.—After many vicissitudes, this map, which I completed last year, has been finally put into the hands of Messrs. Philip & Son; the engraving in black is nearly finished, and although not sufficiently advanced for exhibition at the meeting, it will, no doubt, be completed in two or three months. At any rate, I take this opportunity of heartily thanking the British Association for the kind moral and financial support given to a solitary worker in a foreign country, contending against many serious difficulties. In fact, without such support this work would never have been brought to a successful termination.

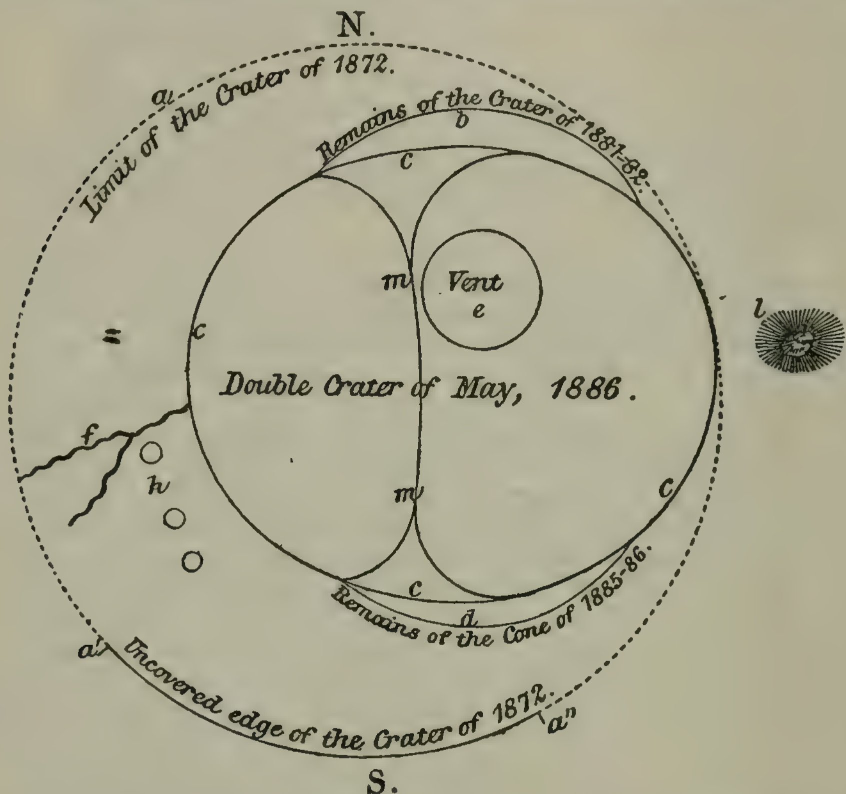
State of Vesuvius.—During the month of June of 1888 the activity at the crater was considerable, coincident with a marked diminution of the oozing forth of lava from the side of the great cone, which lava eventually stopped about the end of the month or beginning of July. Occasionally the edges of the cone of eruption crumbled in, so that ash-ejections were not infrequent. In July, however, the eruptive action was much less and more uniform, nearly always varying from first to second degree, and there was only a slight increment from August 6 to 10. In the month of September, however, the commencement of a marked increase was observable. About this time the eruptive mouth moved in a direction S.W. of the original one, and commenced rapidly building up an eruptive cone. Owing to the increased eruptive action due to the arrest of the lateral outflow of lava from the great cone, by the end of October this eruptive cone was already 20 meters high from the base. The maximum altitude, however, was on the S. side, as the N. wind had been persistent and strong for many days before. This transfer of the vent along a S.W. line was upon that fissure to which I had drawn attention as gradually increasing for many months. The month of November was characterised by considerable activity and marked increase in the height of the eruptive cone.

During December eruptive action was much accentuated, in consequence of which the cone of eruption had continued to rapidly increase, filling about two-thirds of the 1886 crater, leaving a crescentic fossa broadest at the N.E. On the 26th of the month a small opening appeared on the E. side of the cone of eruption, but only allowed of a slight issue of lava. Again on the 28th a little more oozed forth.

On January 1, 1889, this opening enlarged downward, forming a deep notch in the side of the eruptive cone, and allowed a considerable outflow of lava, which filled the crescentic fossa just mentioned and extended to the S.E. and N.W. along its horns, and there stopped. This outflow lowered the central activity for a few days. (Figs. 1, 2, 3.) On January 6 I happened to be in the crater preparing to photograph the cone of eruption, when about one-third the way from its top a slight puff of dust

occurred, followed by the oozing forth of some lava, which rapidly developed into a stream, and by the time my apparatus was ready and in position the crater plain was in part flooded quite close to my camera. My porters abandoned me, and I proceeded to take two instantaneous views. The intense heat, the constant attention to the advancing lava and falling lava fragments, and the whirlwinds produced by the incandescent lava, prevented me observing that a corner of my focussing cloth in part covered the lens. The consequence was that only a corner of one plate showed any picture, and only half of the other was exposed, which is much

FIG. 1.—Diagram of the Summit of the Great Vesuvian Cone, Spring of 1887.



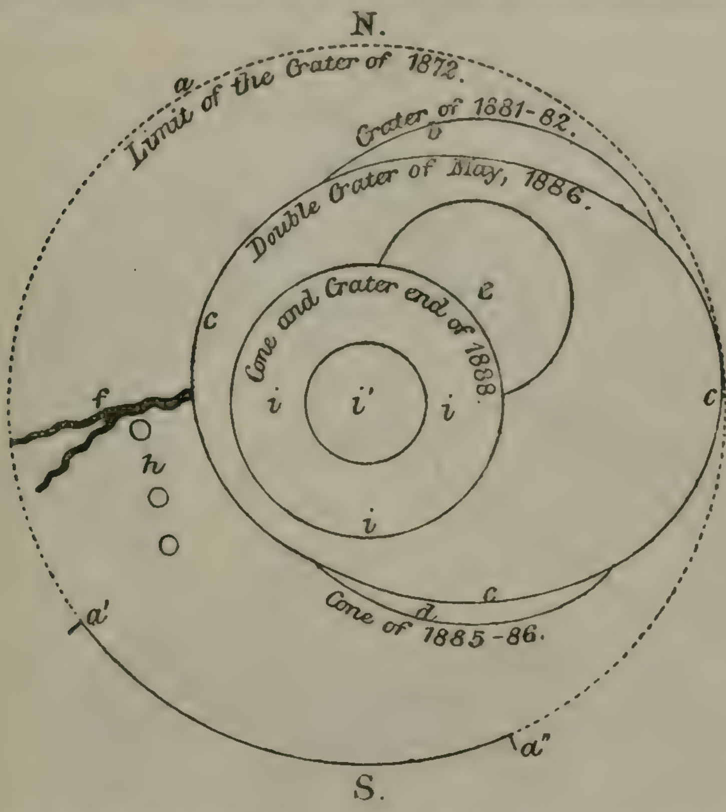
a. Limit of the 1872 crater; the dotted line represents the part covered by overflows of lava at different times since; the part *a′ a″* is still uncovered. *b*, remnants of crater ring of 1881–2; *c*, double crater of May 1886 divided by the ridge *m*; *d*, remnants of the base of the cone of eruption of 1885–6; *e*, active vent; *f*, fissure across 1872, emitting acid vapours; *h*, very ancient hot air passages or fumaroles; *l*, depression on site of the lateral fissure of 1881–2 and May 1886.

to be regretted, as the sight was a very fine one. The lava as it poured forth from the opening gradually carried away the arched roof as this sunk upon the pasty rock, so that the opening eventually became a deep notch in the upper edge of the eruptive cone with the lava flowing along its bottom—in fact, a diminutive baranco. The lava spread rapidly over the crater (1872) plain, so that within half an hour the place I had stood upon could not be approached by many yards. It divided into three tongues: one overflowed the plain edge on to the S.S.E. slope of the cone and descended for about thirty metres, another just overlapped the

edge to the S., and another flowed across the crater plain in a westerly direction; but in two or three hours all outflow and movement of the lava had stopped. I have shown elsewhere that the quantity of outflow is proportioned to the depth of column tapped, but is more than the quantity contained in the chimney above the tapping. This was exactly what occurred in these two cases of January 1 and 6. This outflow slightly lowered the activity for a few days, but observations were much impeded by cloud cap.

On January 19 lava again burst forth to the N.E. and moved forward and outwards, a slice of about a fifth of the cone of eruption, just as

FIG. 2.—Diagram of the Summit of the Great Vesuvian Cone, September 31, 1888.

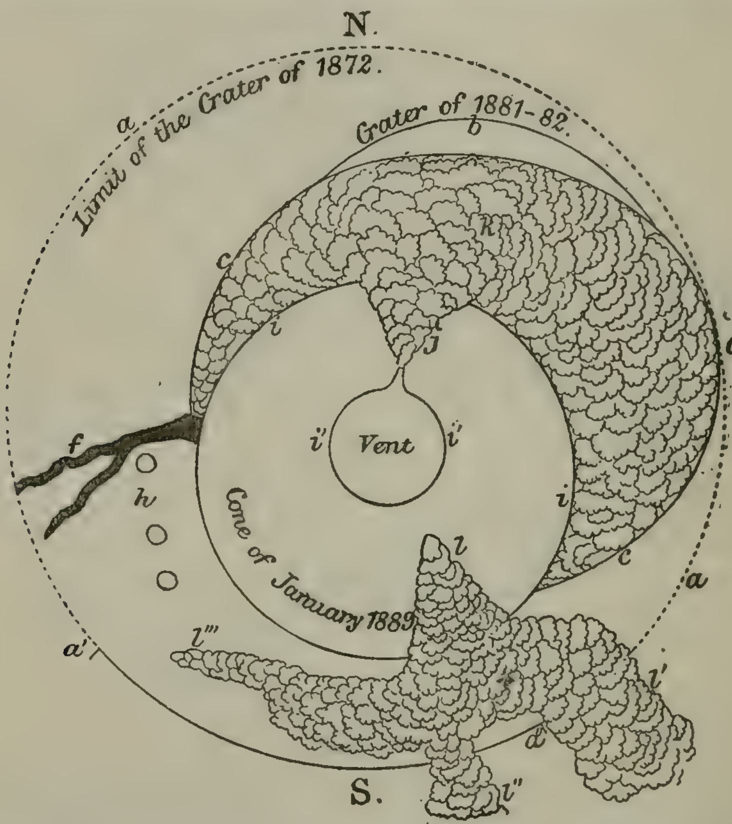


The letters correspond to those of Fig. 1, except the following: *i* indicates the cone of eruption of autumn of 1888; *i'*, the mouth of the volcano.

a partly withdrawn slice of a circular cake. Professor J. D. Dana has lately shown a somewhat similar displacement, though on a very grand scale, in the Hawaïan Islands. The lava issued at a lower level than in the preceding eruption, and therefore flowed more abundantly. It seems to have built up a platform in the eastern half of the crescentic fossa, overflowed its edge and that of the great cone in a N.E. direction. In fact, it is not improbable that it issued by a cleft in the E.N.E. edge of the great Vesuvian cone. Central eruptive activity again diminished for a few days, but returned again about the 27th of the month, so that the ejections rapidly repaired the irregularity in the cone. This restoration of cone-building persisted up to the middle of February, but observa-

tions were very much impeded by cloud cap. On the 11th of that month a slight shock of earthquake is said to have been felt at Resina and its neighbourhood, but no satisfactory account was obtainable. Lava could be seen from Naples flowing on the opposite side of the cone on February 15, as also on the 22nd, 25th, 26th, and 27th. After this the quantity of outflow seems to have diminished, but not to have entirely stopped, for although the activity was fairly marked during March, a slight increase occurred on the 24th, but by the end of the month it practically stopped. The cone continued to increase in height by central eruptive action during the month of April, when, about the 24th, lava again

FIG. 3.—Diagram of the Summit of the Great Vesuvian Cone, January 6, 1889.



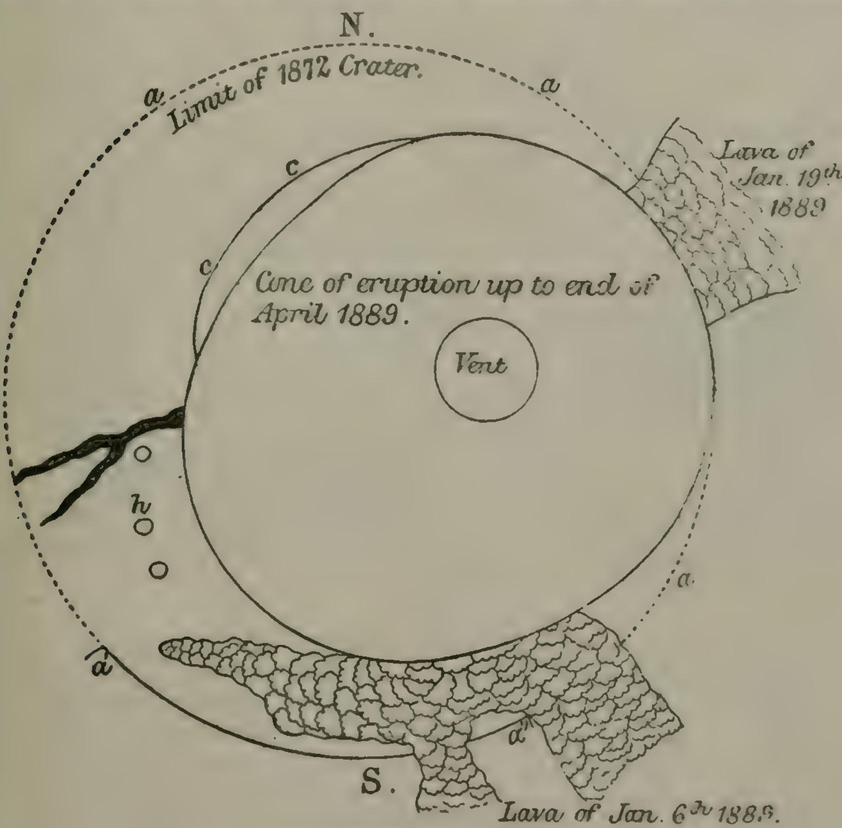
The letters correspond to those of the preceding Figures, except the following: *i*, cone of eruption up to January 6, 1889; *j*, crevass by which the lava of January 1, 1889, flowed; *l*, opening by which the lava issued at 3 P.M., January 6, 1889, which divides into the tongues *l′*, *l″*, *l‴*.

was flowing on the N.E. side of the great cone. (Fig. 4.) On April 29 and 30 and May 1, the slopes of Vesuvius were disturbed by strong and continuous rumbling, and earthquakes were distinctly felt as far as Resina. At 2 A.M. on May 2 (anniversary of the eruption of May 2, 1885), the dyke, which had certainly been in process of formation for some months, and, as I have just shown, had probably already extended down a short way upon the surface of the great cone, giving rise to the constant slight outflows of lava, reached suddenly for a third or more down the great

cone. Simultaneously the eruptive cone which had now reached great bulk, and a height of 40m. to 50m., commenced to fall in consequence of the failure of support from the lava sinking in the chimney, and pouring out through the lateral opening. In about one hour great progress had been made in reducing the cone of eruption to the state of a crater-ring of very considerable dimensions. The outpour of lava had carried forwards the fragments of the crumbling fissure sides so as to leave a chasm 20m. to 30m. wide, along the bottom of which the liquid rock continued to pour, dividing into two streams when it reached the crater plain of the Atrio del Cavallo.

My friend Mr. G. P. Bidder, who was able to visit the seat of eruption

FIG. 4.—Diagram of the Summit of the Great Vesuvian Cone, May 1, 1889.



Lettering as in former Figures.

the following day, found a very considerable outpour of lava, but the progress slow, and the surface much covered by scoria, showing that the first outrush had terminated. Notwithstanding much cloud, a strong reflection from the flowing lava could be seen in the evening.

The rift produced in this disruption is but a few yards to the N. of the old one that has allowed the lateral draining of lava to occur from 1881–2, and several other times during the last eight years. There is little doubt that the radial dyke which caused the 1881–2 eruption has never completely solidified.

The lava was still fairly high in the chimney, as I noticed one faint

explosion from the crater in the evening of May 4, although the gradual disintegration of the cone by crumbling in during the day had made such rapid progress, that the truncation of its summit was most marked. This may possibly be due to partial obstruction of the lateral outflow, as the reflection from the lava was much less. The next day reflection was still less, and the light from the vent almost if not quite invisible. Under favourable circumstances, slight reflection from the lava could be seen from time to time on the cone-slopes.

On May 17 this increased, but diminished during the following days, and during the last five days of the month much black smoke or sand, lapillæ and breccia, were ejected.

The last day of May I found that within the cone a very considerable crater had been formed, perhaps 40m. in diameter, and quite as deep. A mixture of pasty lava cakes, pieces of old lava, and lapillo-sand was being ejected, proving that the molten rock was not far from the bottom of the crater. In fact, the next day the crater showed the first degree of activity, which was maintained between first and second degree during the whole of the month of June, with occasional slight increase in the outflow of lava. During the month of July little change occurred, except from the 6th to the 8th when a markedly increased outpour of lava occurred, and on the 20th and 21st, when more of the crater edge crumbled in, so that for three or four days no reflection from the crater was visible.

During August lava always continued to flow, but increased on the 25th with greater activity at the crater. (Fig. 5.)

Visiting the crater early the next morning, I found that the bottom of it had been raised into a rough plain; about 8m. from the lowest edge in the N.N.W. corner was the eruptive mouth with a low ring surrounding it, constituting the commencement of a cone of eruption.

The fissure crossing the 1872 crater plain in a S W. direction is still very active, giving out abundant exhalations of HCl. There are also indications of weakness at the site of the May eruption of 1885.

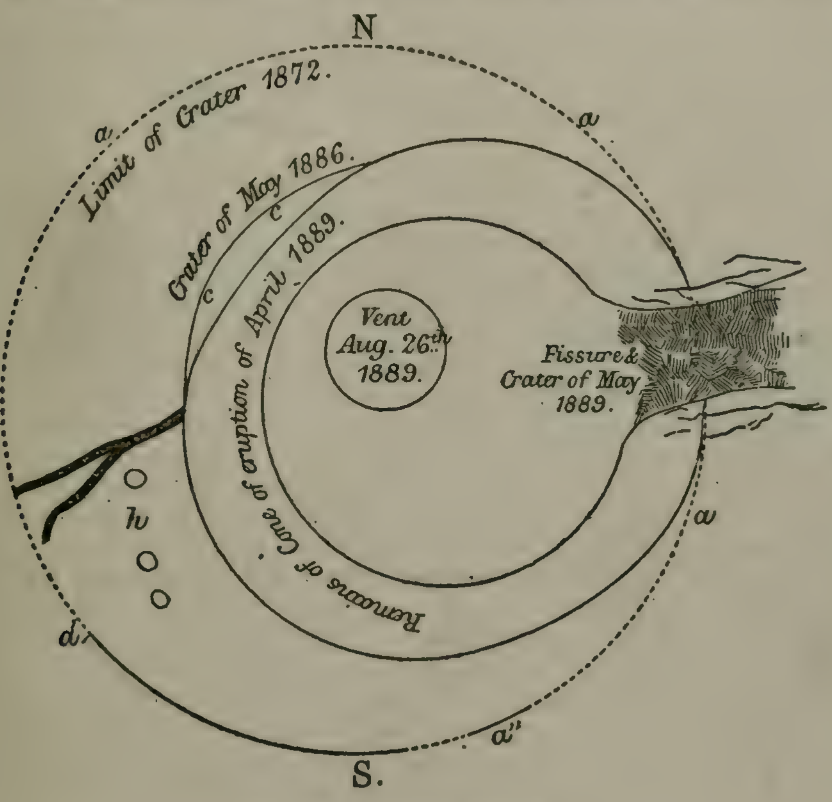
It will be thus seen that Vesuvius has been much more interesting during the present year than last.

Railway Tunnels in the Phlegrean Fields.—Much progress has been made with the two tunnels near Baja, of the new railway line. The first, or that one that enters the hill at the Baths of Nero, had been commenced before my last report, and is one that I had shown to present great difficulties in its construction. This proved to be the case, for the temperature very rapidly rose as the work progressed, so that 70° to 80° C. was the normal temperature of the working atmosphere, which rose higher when a new face of rock was detached. In a hole made in the newly exposed rock, a maximum temperature of 93° C. was registered by one of the engineers. The workmen, absolutely naked, worked but an hour or two at a time, and came out much exhausted. I myself visited the works on various occasions, my only costume being socks and boots, and I could well appreciate the great difficulties of persistently and violently exercising oneself in this highly heated, and, above all, moist atmosphere. Fortunately, the tunnel is slightly inclined, and when work was stopped at the lower end, it was proceeded with, with much greater ease, from the upper end, until at last a headway through was opened up, after which the temperature rapidly fell.

Of great interest is the fact that a number of Roman cuniculi have

been encountered crossing the tunnel at various angles and at different levels. Many of these are inclined passages, just large enough for a man to descend, quite similar, in fact, to those at the Baths of Nero. Where these passages reach the drainage level, they are filled by hot mineral water. The tunnelling continues on for some distance beneath the water, so that it is impossible to know how the original excavation terminates. The present state shows that we have confirmatory evidence of subsidence since Roman times. Others have a horizontal course and extend into the hills, for in some cases over 100 meters. One of these was in sufficient repair for careful observation. It enters the mountain near the road to

FIG. 5.—Diagram of the Summit of the Great Vesuvian Cone, August 26, 1889.



Lettering as in former Figures.

Baja, and close to the first pozzolana quarries, after passing the Baths of Nero, and follows a perfectly straight course, till it reaches just above the top of the railway tunnel. About 50m. before its termination it divides into three, one of which descends and terminates in a very hot water, just beneath the railway tunnel. The other two branches run one above the other, the lower of which, after a short distance, turns suddenly to the right or E., and descends almost perpendicularly to join another cuniculus, which, running backwards towards the road, soon divides into two, but is choked by the falling in of the roof. This last presents thick incrustations on its walls, and on a rubble-wall support, put in at one place, at a later date, thick deposits of hyaline silica, which in some cases is crystalline, presenting apparently very minute crystals of quartz; at

other spots occur crusts of finely crystalline gypsum. Of the two branches of the long cuniculus the lower terminal one exhibits a few deposits of hyalite, gypsum, and carbonates of potash. It is, however, the upper branch, or really the continuation, of the main cuniculus, though at a higher level, that is of the greatest interest. The whole length is covered with saline crusts, ranging from 1 to 10 c.m. in thickness. This thickness does not represent the entire thickness that has been formed, for on the floor one scrunches through a considerable thickness of old crusts that have become detached, and are now replaced by new ones. Most of the material, so far as a few qualitative tests go, that I have had time to make, shows the principal part to consist of carbonates of potash, with some soda, traces of H_2So_4 and HCl. There are certainly two, if not three varieties of different hydration. The crusts are all crystalline, but of a fibrous character, so that the crystalline form is not discernible, although I do not despair of detaching a few minute but measurable crystals. In some parts of the cuniculus, the walls, floor, and roof were covered by a capillary deposit, the flexible filaments attaining 3 to 4 c.m. in length.

This upper branch-cuniculus terminates by a passage descending nearly at an angle of 45°, but for only 2 meters. Whether this extended further, or has been blocked by a collapse of the roof, is not easy of determination, as the whole is very thickly covered by the saline crusts.

The temperature in this upper cuniculus I found to register 73° C., though now the ventilation must be improved by the two other branches having been put in communication with the new railway tunnel.

At the time this temperature was taken I was unwise enough to attempt to photograph the interior by magnesian light. I was accompanied by one of the boys accustomed to the great heat of the railway tunnel. Various attempts were made to illuminate such a long narrow passage, but I regret to say unsuccessfully. Although perfectly naked, a stay of over half an hour in this temperature so exhausted us that when we retired to the main cuniculus, where the temperature was much lower, I became almost insensible, my heart and arteries throbbed violently, and yet I could hardly move a limb from extreme weakness. I remained in this state for some considerable time until sufficiently recovered to partly dress and get to the open air; the effort to do which brought back all the symptoms, and I only recovered after drinking freely of some strong wine brought me, and taking some food. My porter, habituated to these high temperatures, suffered very much, but recovered quicker. The symptoms I am inclined to attribute to carbonic acid, as after a short time there we were much troubled by tingling of the conjunctiva. The proportion could not have been great, as the nasal membrane did not smart; we felt no immediate difficulty of breathing, and our composite candles burnt freely, although they gradually melted down. I am accustomed to the sensation of entering an atmosphere of carbonic acid, and so far as I could judge, this was the cause of our indisposition. That it was not simply heat is proved by the boy suffering, although accustomed to even a higher temperature for longer periods.

I have gone into these symptoms as having an important bearing on the volcanological history of this spot. In the first place, the Baths of Nero prove to us that this point has undergone a similar oscillation of level to that of the temple of Serapis or Pozzuoli; in the next, that there

has been a marked rise in temperature of this neighbourhood since these cuniculi were made, as I maintain that if we, in a half hour exerting ourselves but slightly, were so indisposed (in my own case I may say gravely), it would have been perfectly impossible for workmen to cut out the compact tufa at the end of a narrow cuniculus just large enough to allow a medium-sized man to walk upright, and to transport the materials for 50m. along this hot passage, and then for another 100m. along a cooler one. 73° C. was the temperature we experienced, but no doubt it had been lowered by the circulation set up in the other branches from the new railway tunnel, and the mephitic atmosphere must also have been improved. There remains, therefore, but one explanation, and that is that here the temperature has increased during the last two thousand years. I do not, however, suppose that the ground was cool, as we have historic evidence that the so-called Baths of Nero, and all the district, was renowned in Roman times for its thermo-mineral waters; and the inclined passages seem to indicate that they were used for bringing the water up, as they are nearly all in relation with the ruins of thermae I only maintain that the temperature has augmented considerably, and seems to indicate the localization of future eruptive action to this locality. The long horizontal passages I take to have been made to collect the vapours for the sudatorii, and the connection I have really seen to exist in one place. If I am wrong in my conjecture as of general application, I am open to correction by competent archæologists.

The material of the whole of this first of the tunnels at Baja is composed of a somewhat friable porous tuff, in some parts yellow, and in others light green. Towards the western end the tuff is more stratified, and less altered, being composed of bands of white pumice imbedded in a buff-coloured dust. All the large masses of pumice in the three varieties of tuff are much altered on their surface into a white powdery substance, probably kaolin.

The second tunnel from Baja to Fusaro was made through very much cooler ground, consisting of a rather loose tuff of pozzolana with masses of large pumice. In this one a number of cuniculi were also cut through, and two of the inclined ones I was able to examine. The first, on the left, communicated with a Roman bath-room, a short distance in from the Baja entrance, and on the right descended to some hot water with a temperature of 57° C. Another one, some considerable distance further along on the same side, descended to hot water of 67°. The stones at the bottom of the little pond of water I noticed to be of an intense black colour, and on removing these they were seen to be covered by a wet sooty deposit of from 0·5m. to 1m. in thickness, and smeared over at spots with gelatinous silica, so as to have the appearance of wet stringy mucus. Although the simile is not elegant, the appearance was such that I thought, on withdrawing the first example, that some workman had spat upon the stone. A qualitative analysis proves this black deposit to be a hydrated oxyde of manganese; it must have been deposited from a water very rich in some salt of that base.

During last autumn dredging operations were carried on just W. of the wooden pier at Pozzuoli, belonging to Messrs. Armstrong's works; they brought to the surface upwards of forty beautifully carved capitals and pedestals of small columns from a point which, by tradition, was the situation of the Temple of the Nymphs.

This fact is of value as another confirmation of the general depression of the land in this district since Roman times.

Excavations in Naples.—The continuation upwards of the funicular railway tunnel at Monte Santo, Naples, fully confirms the suppositions put forward in last year's Report in regard to the succession of the deposits cut through. Overlying the great deposit of coarse breccia is a series of pumices and ashes, with intervening vegetable soils and carbonised branches, identical with the strata of the Parco Grifeo (Corso Vittorio Emanuele), synclinal, showing that the Monte Santo grey tuff and breccia occupies the same stratigraphical position as the blocks of piperno and the remnants of a similar breccia met with all along the Corso V.E. at Naples. The constant occurrence of the yellow Neapolitan tuff deposited upon undoubtedly subaerial surfaces shows that that material is of subaërial origin, and not submarine as some volcanologists suppose, because a few marine shells occur in it: these may really be regarded simply as ejected blocks of 'accidental' origin.

The work for the lower end of the tunnel has been suspended pending a lawsuit, so that the relation of the Rione Amedeo tuff to the Cumana Ry. trachytes is still unsettled. When this point is cleared up I shall have made out the stratigraphical order of the Campanian volcanoes—a necessary foundation for their correct study.

Returning to the extraordinary collection of rocks contained in the Monte Santo, Soccavo and Pianura coarse breccia, I have an important addition to make in the form of a block of brownish rock with rhombododecahedra (?), having all the characters of decomposing haüyne. The rock is, in fact, indistinguishable from some of the haüynophyres of Monte Vultura. As soon as the microscopic preparations of the rock are finished (if these prove to be its true nature) it will be its first recorded occurrence amongst the Campanian volcanoes—a point of no small interest when we remember that it is one of the earliest erupted materials of the district, and its similar relationship to the leucitic rocks at Monte Vultura and elsewhere. This block is from the Monte Santo funicular tunnel.

The section exposed by this tunnel, so far as completed, is the following:—

Superficial dust and pumice beds (Astroni deposits and others ?), 15m.

Compact yellow tuff of Naples (building stone of the town), 50m. or more.

Purplish grey or black dust, old vegetable soil, 0·20m.

Passing down into fine grey dust, 1·50m.

Grey pumice and dust bed, 0·45m.

Dust bed, grey at bottom, purple-grey or black at top, 0·35m.

Parco Grifeo lapillo bed, with pumice, rather fresh, 0·45m.

Four pumice beds, with their dust beds of grey colour, and semi-compacted, about 1·50m.

Coarse incoherent breccia, composed of blocks up to half a cubic metre in volume, consisting of vitreous piperno (of lava), porphyritic sanidine obsidian (glassy trachyte), trachytes, dolerites, leucite lavas, haüynophyre, basalts, tuffs of different kinds—some solfatarised, others with organic remains, besides many other varieties of rock.[1] The essential material is

[1] On account of the great variety of rocks contained in this deposit a friend suggested calling it 'the museum breccia,' and, wanting some designation for it, I intend to so name it in future.

represented by a fibrous, silvery grey pumice. The upper part is composed of 2m. of coarse gritty sanidinic sand, with minute fragments of the different rocks beneath, and represents the diminution of the eruptive activity. Finally this passes up into 0·7m. of reddish gritty earth, representing the last ejections of fine ash, eventually converted into vegetable soil: at least 12m.

Grey pipernoid tuff, quite similar to that of Nocera and other localities, containing fragments of marialite-bearing piperno—the lowest, 0·30m., reddened; about 4·30m.

Black dust band, 0·10m.

Bed of coarse masses of light coloured pumice, the upper third reddened, 0·80m.

White pumice interbedded with thin dust bands, some buff and others red, conformably under last, 4·00m.

Rather uniform bed of nearly pure small white pumice, 0·90m. lying conformably on.

Brown ashy tuff, with bands of white pumice, 4·00m.

Grey pipernoid tuffs of the Campania.—The remarkable relationship of this section, together with that of Pianura-Soccavo to the grey tuffs that crop out all round the Campanian plain has led me to examine these further. Although that examination is not completed it is advisable to give the results, as already the number of facts I have collected is sufficient to afford some explanation of this remarkable deposit.

Professor A. Scacchi, in a series of valuable memoirs on the peculiar metamorphism that the enclosed fragments of limestone exhibit, has touched upon the origin of this tuff. On account of its slight variation in colour, the number of enclosed scoria fragments and the different degrees of alteration of the enclosed limestone blocks, he supposes that innumerable eruptive mouths have broken out around the bases of the limestone mountains, from which volcanic mud has been poured forth and blocks of limestone ejected, which had already been to some extent acted upon by hydrofluosilicic acid. Now, when we examine this deposit in the field, we find that it chokes all the valleys, forming an important deposit 20 to 30 kilometres around the actual limits of the Campanian plain. To explain such deposits it would be necessary to admit the existence of hundreds of eruptive mouths, or to suppose that these great streams of mud had actually flowed up instead of down the valleys. In the next place, I have met with important deposits of this tuff, as much as 500 meters or more above sea level. There are dozens of such localities known to me, where a slight interruption on the steep slope of a mountain has permitted this material to resist the denuding agencies. In some of these localities the limestone rock above the deposit is bare right up to the summit, and there is no eruptive mouth visible. We must therefore conclude that this tuff was not mud, since there is nowhere from which it could have flowed. It is evident that it was an ash that fell, and, swept down the mountain by rain, was converted into mud; this is quite different from the supposed eruption of mud, still a questionable phenomenon from real volcanoes. Neither is there evidence of a single eruptive orifice; and all the variations can be explained by wind action, which would carry scoria fragments more in one direction than in another, and, by changing during the eruption, cause irregularity of distribution in any

one locality. Besides, the fineness of the tuff increases as we recede in all directions towards the periphery of the deposit.

My experience is that the presence of limestone fragments is limited to the close proximity of steep slopes of that rock, and that as we increase the distance from the evident source, their quantity diminishes. In the same manner I found (though with some uncertainty) that the amount of metamorphism was in direct proportion to the development of the tuff, simply because there was more of the fluoriferous reagent to act upon the calcic carbonate.

As a further confirmation of the relative age of this grey tuff, I met with a striking piece of evidence at the village of Pastena near S. Agata di Sorrento; here the tuff has been worked to a depth of three or four meters, but I could not see its base. It forms fairly regular columns, and is overlain by recent alluvial deposits with Vesuvian pumice. In one or two places between these two deposits small pockets or depressions are filled by a breccia almost identical in components with that of Monte Santo, Pianura, and Soccavo. The fragments of vitreous trachytic scoria attain the size of a fist, but the more compact trachytes, solfatarised tuffs and leucite lavas (rare) exceed the size of two walnuts. Some of the scoria is strikingly similar to the wood-like masses above the breccia at Soccavo. The breccia has all the appearances of having been rearranged by water, and therefore, probably, is the equivalent of the many-rock breccia, the Grifeo lapillo beds and its associated pumice and ash deposits. The only difference that I could find was a somewhat greater abundance of leucitic rocks.

The other excavations in the vicinity of Naples have brought little to light; but the numerous trenches that are already commenced for the new sewerage system will undoubtedly afford a large amount of new and valuable evidence. In fact, the next year must be looked upon as the most important up to the present, and for many years to come, as being the one in which the most valuable geological facts will come to hand. Those new data will, no doubt, to a great extent, settle the more important questions bearing on the geology of this region, and some of volcanology in general.

Liberated as I am from the monotonous work of the mapping of Vesuvius and Monte Somma, I propose to devote myself to the study of these sections, and the results they afford; and, should circumstances be favourable, also to the investigation of some of the physics of fluid lava. I have a large amount of material on hand, but await publishing this until further excavation confirm or modify the conclusions drawn therefrom. Many of these important discoveries will be open to the party of English and foreign geologists, who will visit this district immediately subsequent to the present meeting. This excursion, the first of its kind, has been organised at my instigation by that active body, the Geologists' Association, in conjunction with the Geological Societies of London and Italy, and under the hospitable patronage of the Italian Government, and especially the Minister of Public Instruction, Signor Boselli.

Ninth Report of the Committee, consisting of Mr. R. ETHERIDGE, Professor THOMAS GRAY, *and* Professor JOHN MILNE (*Secretary*), *appointed for the purpose of investigating the Earthquake and Volcanic Phenomena of Japan.* (*Drawn up by the Secretary.*)

THE GRAY-MILNE SEISMOGRAPH.

THE seismograph which was constructed in 1883, partly at the expense of the British Association, although it is not so complete as types of the same seismograph which have been constructed subsequently, still continues to be used as the standard instrument. The earthquakes which it has recorded since the publication of the last report up to March 4 of this year are given in the accompanying list.

Catalogue of Earthquakes recorded at the Meteorological Observatory, Tokio, between June 1888 *and March* 1889 *by the Gray-Milne Seismograph.*

No.	Month	Date	Time	Duration	Direction	Maximum Amplitude: Period in secs.	Maximum Amplitude: mm.	Maximum Velocity per second, mm.	Maximum Acceleration per second, mm.
			1888.						
			H. M. S.	M. S.					
826	VI.	12	9 6 27 P.M.	0 20	S. 21° 30′ E.	1·2	0·4	1·0	5·0
827	”	15	0 21 25 A.M.	—	—	very	slight	—	—
828	”	18	2 20 31 P.M.	1 40	(S.E.–N.W.) N. 35° 30′ W.	0·8	0·3	1·2	9·6
829	”	”	3 17 6 P.M.	—	—	very	slight	—	—
830	”	”	9 57 14 P.M.	—	—	very	slight	—	—
831	”	19	6 29 57 A.M.	abt. 0 20	E.–W.	0·8	0·2	0·8	6·4
832	”	22	7 6 25 A.M.	—	—	very	slight	—	—
833	”	24	11 8 20 P.M.	0 10	E.–W.	very	slight	—	—
834	VII.	2	4 51 56 A.M.	—	—	very	slight	—	—
835	”	7	9 37 37 A.M.	3 0	E.–W.	sli	ght	—	—
836	”	”	5 25 43 P.M.	1 0	—	sli	ght	—	—
837	”	11	3 38 35 P.M.	—	—	very	slight	—	—
838	”	14	7 31 59 A.M.	—	—	sli	ght	—	—
839	”	”	4 42 44 P.M.	3 0	S.S.W.–N.N.E.	2·4	0·6	0·8	2·1
840	”	22	2 27 48 A.M.	—	—	very	slight	—	—
841	”	24	7 57 43 A.M.	—	—	very	slight	—	—
842	”	29	9 48 21 P.M.	1 30	E.–W.	1·0	0·2	0·6	3·6
			vertical motion	—	—	very	slight	—	—
843	VIII.	1	9 25 18 P.M.	1 30	E.–W.	0·8	0·2	0·8	6·4
844	”	11	9 31 42 A.M.	—	—	sli	ght	—	—
845	”	12	11 42 27 A.M.	3 0	S.S.W.–N.N.E.	1·2	0·4	1·5	11·2
846	”	17	3 49 50 A.M.	1 10	E.–W.	1·0	0·2	0·6	3·6
847	”	18	1 22 0 A.M.	—	—	very	slight	—	—
848	”	19	9 19 26 A.M.	—	—	very	slight	—	—
849	”	”	11 47 25 A.M.	—	—	very	slight	—	—
850	IX.	2	5 45 0 A.M.	0 30	E.–W.	very	slight	—	—
851	”	4	5 10 0 A.M.	—	—	very	slight	—	—
852	”	”	1 36 11 P.M.	—	—	very	slight	—	—
853	”	5	0 6 35 A.M.	—	—	very	slight	—	—
854	”	6	4 9 25 A.M.	—	—	very	slight	—	—
855	”	10	9 22 0 A.M.	—	—	very	slight	—	—
856	”	11	8 34 54 A.M.	0 25	E.–W.	0·4	0·4	3·1	48·0
			vertical motion	—	—	sli	ght	—	—
857	”	18	2 45 39 A.M.	0 30	E.–W.	sli	ght	—	—
858	”	24	5 24 30 A.M.	0 20	E.–W.	very	slight	—	—
859	”	”	5 37 13 P.M.	—	—	very	slight	—	—
860	”	28	7 5 21 A.M.	0 30	E.–W.	very	slight	—	—
861	X.	9	1 7 55 A.M.	—	—	sli	ght	—	—
862	”	10	4 20 24 P.M.	0 30	—	sli	ght	—	—
863	”	12	7 40 56 A.M.	—	—	sli	ght	—	—

CATALOGUE OF EARTHQUAKES—*continued.*

No.	Month	Date	Time	Duration	Direction	Maximum Amplitude: Period in secs.	Maximum Amplitude: mm.	Maximum Velocity per second, mm.	Maximum Acceleration per second, mm.
			H. M. S.	M. S.					
864	X.	20	6 15 16 A.M.	2 0	N.N.E.–S.S.W.	0·5	1·2	7·5	93·7
			vertical motion	—	—	0·5	0·5	3·1	38·4
865	XI.	2	1 48 1 P.M.	1 0	E.–W.	0·8	0·3	1·2	9·6
866	”	3	0 51 14 A.M.	1 30	E.–W.	0·5	0·3	1·9	24·1
			vertical motion	—	—	slight		—	—
867	”	”	8 13 33 A.M.	4 30	S.W.–N.E.	0·4	1·9	14·4	232·6
			vertical motion	—	—	0·4	0·5	0·4	0·6
868	”	5	4 22 55 A.M.	—	—	very slight		—	—
869	”	6	4 38 37 P.M.	3 0	—	2·2	0·2	0·3	0·9
870	”	7	10 27 34 P.M.	4 0	E.–W.	3·5	0·5	0·4	0·6
871	”	10	1 37 44 P.M.	1 30	W.N.W.–E.S.E.	1·8	0·3	0·5	1·7
872	”	16	0 42 52 A.M.	—	—	very slight		—	—
873	”	20	0 53 29 A.M.	2 30	E.–W.	0·9	0·2	0·7	4·9
874	”	22	1 27 43 P.M.	—	—	very slight		—	—
875	”	23	5 13 30 P.M.	—	—	very slight		—	—
876	”	24	2 3 23 A.M.	4 0	N.W.–S.E.	1·4	0·4	0·9	4·5
877	”	25	4 50 15 P.M.	0 15	E.–W.	0·5	0·2	1·3	16·9
878	XII.	3	0 24 47 P.M.	2 0	S.E.–N.W.	1·8	0·2	0·4	1·6
879	”	6	7 27 42 A.M.	—	—	very slight		—	—
880	”	16	4 19 3 A.M.	0 20	S.–N.	slight		—	—
881	”	28	3 28 4 A.M.	0 35	E.–W.	1·7	0·2	0·4	1·6
					1889.				
882	I.	1	4 50 P.M.	0 12	S.W.–N.E.	0·3	0·5	0·5	1·0
			vertical motion	—	—	very slight		—	—
883	”	”	7 5 30 P.M.	1 55	S.W.–N.E.	0·15	1·1	23·0	961·8
			vertical motion	—	—	0·3	0·5	0·5	1·0
884	”	3	7 58 6 A.M.	2 0	E.–W.	1·5	0·8	2·5	15·6
885	”	12	8 34 3 P.M.	—	—	very slight		—	—
886	”	27	2 28 47 P.M.	—	—	very slight		—	—
887	II.	5	2 27 39 P.M.	0 5	S.–N.	slight		—	—
888	”	6	3 20 5 P.M.	2 0	E.–W.	slight		—	—
889	”	9	7 41 38 A.M.	0 10	S.–N.	very slight		—	—
890	”	15	5 14 3 P.M.	—	—	very slight		—	—
891	”	18	6 9 32 A.M.	6 12	(N.W.–S.E.) S. 42° 10′ E.	2·2	20·3	29·0	83·3
			vertical motion	—	—	0·6	3·7	11·6	72·7
892	”	”	6 27 45 A.M.	2 0	S.W.–N.E.	—	0·2	—	—
893	”	”	7 48 52 A.M.	2 0	E.–W.	slight		—	—
894	”	”	about 8 2 0 A.M.	—	—	very slight		—	—
895	”	”	10 10 56 A.M.	0 30	S.E.–N.W.	slight		—	—
896	”	19	2 57 43 P.M.	0 15	S.–N.	slight		—	—
897	”	20	9 19 37 P.M.	—	—	very slight		—	—
898	”	21	5 52 21 A.M.	0 15	E.–W.	slight		—	—
899	”	”	8 19 23 A.M.	0 20	S.–N.	slight		—	—
900	”	”	11 1 4 A.M.	0 30	—	very slight		—	—
901	”	”	9 27 52 P.M.	0 15	S.–N.	slight		—	—
902	”	23	11 27 21 P.M.	0 13	S.–N.	slight		—	—
903	III.	3	4 35 19 P.M.	0 30	E.–W.	—	0·2	—	—
904	”	4	7 24 25 A.M.	—	—	slight		—	—

The most severe earthquake which was recorded occurred on February 18, 1889, at 6h. 9m. 32s. A.M. Diagrams of this earthquake were obtained at the Imperial Meteorological Observatory, and by Professor S. Sekiya and myself at the University. All of these observations were made upon ground which is tolerably high, and although consisting of alluvium it is fairly hard. This is mentioned because the motion experienced in the lower part of the city, which is built upon soft low ground, and at places nearer the origin was certainly greater than that which we recorded. Professor Sekiya says that after the commencement of the shock there were gentle tremors lasting twelve seconds. These were followed by violent motions having a range of a little less than 12 millimetres in a

direction about N. 60 E. At my own home the range of motion was fully 12 millimetres, and the direction of motion was between N.N.E. and N.E. At the Meteorological Observatory the range of motion was 20 millimetres with a period of 2·2 seconds. The period of vibration recorded by Professor Sekiya was 1·9 second. From these quantities it appears that the least maximum velocity was 16·5 millimetres, whilst the maximum acceleration per second per second was 54·6 millimetres.

At the Imperial Observatory these quantities were respectively 29 and 83 millimetres. For two minutes the motion was severe, and Professor Sekiya's instruments recorded a continuous motion for 8 minutes 6 seconds. The greatest vertical motion was 1·4 millimetre, and it was simultaneous with the greatest horizontal motion. Its period was one second. Between the time of occurrence of the first shock and 10 A.M. there were four minor disturbances.

In Yokohama, which is sixteen miles distant from Tokio, and which in all probability is sixteen miles nearer to the origin of the shock than Tokio, several buildings sustained injury. A number of chimneys were overthrown, several were turned; on several roofs tiles were shaken up and dislodged, while several walls were cracked and fractured. There are no records from seismographs with which this damage may be compared, but from previous observations made in Yokohama and Tokio, I am of opinion that the maximum acceleration experienced in Yokohama was almost 100 or more millimetres per second per second. Reports were obtained from many towns in the country; but although the shock was severe no damage occurred.

To compare this earthquake with others relatively to the effects they have produced on buildings, the following two records from seismographs placed in Tokio are reproduced.

On January 15, 1887, an earthquake occurred which had a maximum acceleration of 66 millimetres per second per second in soft ground, and 36 millimetres per second per second on hard ground. In Tokio a few brick walls were slightly cracked; but in Yokohama, which was about ten miles from the origin, it destroyed several chimneys and slightly shattered a few buildings.

On February 22, 1880, an earthquake occurred, when in Tokio several chimneys fell, and here and there tiles were dislodged, and a few walls were cracked. In Yokohama the destruction was considerable; windows were broken, grave-stones rotated, chimneys were overturned, and several homes were unroofed. In Tokio it seems that the acceleration was about 90 or 100 millimetres per second per second.

In connection with the earthquake of February 18, I may mention that I was called upon to join in an official inspection of several public buildings. One building inspected, which is probably the largest brick building in Tokio, rises with free sides from a basement. In this building there was no damage whatever. Another heavy brick building very near to this, which rises from ordinary foundations, and without a free area, showed cracks in almost every room.

On the Distribution of Earthquake Motion in a small Area.

In the report of last year it was mentioned that experiments had been commenced to approximately determine how far earthquakes were *felt* in different parts of Tokio. To do this I distributed through the city of

Tokio and its suburbs, or over an area measuring about 6 miles by 7 miles, 134 bundles of postcards. Each card, which was addressed to myself, had upon it in English and Japanese the following request:—'If you or your neighbours feel an earthquake, kindly post this card, giving the *date* and the *time* of the shock, and saying whether it was *short*, *long*, a *tremor* or a *jerk*; were you upstairs or downstairs?' With each bundle, in which there were 20 cards, there was a letter of more detailed instructions. Great care was taken in the distribution of these cards; and they were all held by persons competent, and who expressed a desire to make the necessary observations. Seventy-five observers were situated on high ground and fifty-nine on low ground. The high ground is from 50 feet to 100 feet above sea-level, on the western and northern sides of the city, and it overlooks the lower part of the city from bluff-like scarps. It consists of 30 or 40 feet of loam, thin bands of clay, and 60 or 80 feet of sand and gravel. Below this there is a clay-like tuff rock. The low ground, which is flat almost to sea-level, consists of mud, clay, and sand, after which comes tuff. The thickness of these materials lying on the tuff is anything between 20 and 500 feet. In addition to the postcard observers there were many who communicated with me by letter. I also received the records of the Imperial Meteorological Observatory, from which I could determine the area over which any earthquake extended, and the records from two observatories under the direction of Professor Sekiya, and the observations made by myself. Altogether, within the 30 square miles where I made observations I had about 150 correspondents. The general results of the observations were as follows:—

Out of 2,010 postcards which were distributed between November 15, 1887, and May 5, 1888, a period of nearly six months, 103 observers sent in 496 records. Thirty-one observers, 14 of whom lived on the high ground, and 17 lived on the low ground, although it seems impossible that they should not have felt at least one of the 69 shocks recorded, did not return a single card.

The balance of unused cards amongst actual observers up to May 5 was 1,064. Many of these since that date have been returned, but they have not been used in the following investigations, inasmuch as other observers had by May 5 exhausted the stock of cards with which they were provided.

The 496 records were made as follows:—370 came from 61 observers living on high ground—that is, upon the western and northern side of Tokio; while 126 records came from 42 observers living on the low ground.

The average number of records per observer on the high ground was 6, while upon the low ground the average was 3.

The greatest number of earthquakes were therefore observed by residents on the high ground.

The disturbances which were only felt in Tokio were at least 25 in number. In 8 other cases, as the shock was only recorded by one observer, it is possible that a mistake may have been made in observation. All these earthquakes, with the exception of one which is said to have been felt upon the east side of the city, were only felt upon the hilly hard ground upon the western and north-western side of the city.

The disturbances which were felt in Tokio, and which in addition also shook a large tract of country surrounding the city—in some cases the whole coastline for at least 200 miles—were 36 in number.

From this it appears that about ·41 per cent. of the shocks felt in Tokio are of local origin.

The 36 shocks which were felt in Tokio, and which shook a large tract of country, may be subdivided as follows:—

1. Shocks which were felt all over Tokio. These are 6 in number.

2. Shocks which practically were only felt upon the hilly hard ground upon the west side of Tokio. These are 30 in number.

From the above we may conclude that 36 per cent. of the earthquakes which shake an enormous area of ground outside Tokio only shake the hilly part of Tokio itself.

From maps of shocks which shook a large area but only shook the hills on the west side of the city, I find from records kept by Mr. E. J. Pereira of Yokohama, which lies from Tokio about 16 miles S.S.W., that at least 10 such shocks were felt in Yokohama. Had Mr. Pereira been provided with a proper instrument, or had he had the assistance of other observers, it is probable that he might have recorded a still greater number of this particular kind of disturbance.

I. *Shocks which shook a large area of country, and the whole of Tokio.*

The No. of the Shock	Period in Seconds	Average Period	Area shaken in Sq. Ri.
2	·2	1·1	1,362
16	1·5	1·25	2,260
19	·6	—	—
83	3·7	2·	3,440
60	1·2	·7	4,060
66	·8	·77	5,080
Average . .	1·33	·76	3,240

II. *Shocks which shook a large area of country, but which only shook the hilly part of Tokio.*

The No. of the Shock	Period in Seconds	Average Period	Area shaken in Sq. Ri.
1	2·4	2·5	1,460
3	—	—	670
7	1·2	1·66	1,710
12	·5	—	—
17	—	—	720
28	1·8	1·3	1,480
32	—	—	180
34	1·4	1·4	1,680
35	—	—	730
36	2·4	2·2	2,630
38	2·1	1·4	9,670
40	—	—	160
41	—	—	880
46	—	—	170
48	3·2	2·5	5,220
50	—	—	580
51	—	—	580
52	—	—	690
53	·2	—	520
54	—	—	1,470
55	·8	—	1,990
56	·8	—	1,990
Average . .	1·52	1·85	1,680

From the above tables, which give the period and area shaken by each of these shocks, we see that the shocks which disturbed the whole of Tokio each had on the average at the same time shaken a much larger area than those which were only noticed on the high ground.

Further, those which were felt by the residents on the low ground had on the average a much shorter period than those which were only felt on the high ground.

This latter observation may explain why so many shocks are not recorded on the low ground.

Another explanation is that in many instances a vibratory motion passing beneath Tokio may only reach the surface where the superincumbent soft materials are thin—that is, upon the hills—the relatively thick deposit of soft material on the low ground absorbing the motion like a buffer.

There were 19 shocks which the instruments at the Imperial Observatory did not record. Out of the 19, however, 8 disturbances had only been felt by one observer, and therefore we cannot say with certainty that there were more than 11 shocks which the Central Observatory failed to observe. On the other hand, there were 10 shocks recorded at the Observatory which were not observed by any of the 134 observers in the city. The most probable reason why 11 earthquakes were unrecorded at the Observatory is because these disturbances were too limited in area to reach the district where it is situated. One conclusion we arrive at is, that a set of seismographs located at an Observatory in a city like Tokio, no matter how carefully they may be looked after, cannot be expected to record more than 80 per cent. of the total number of earthquakes felt in that city.

Another conclusion resulting from these observations is that residents on the high ground upon the western and northern sides of Tokio feel more earthquakes than residents who live upon the low ground towards the south and east. One explanation for this is that the movement upon the low ground is slower than that on the high ground; but to place this explanation on a more certain foundation, it is necessary to make instrumental observations.

A certain number of earthquakes, however, appear to have originated beneath the high ground in the Kojimachi-Akasaka districts, and do not appear ever to have extended to the low ground. This fact will always make the high-ground disturbances more numerous than those felt upon the low ground. When I was resident within the area of local disturbances near Toranomon I came to the conclusion that these local shocks might in many instances be recognised by their character, which is that of a small but sudden little tip from beneath, the vibrations, which only continue two or three seconds, causing hanging lamps to oscillate vertically.

So far as safety is concerned, notwithstanding the above observations, I am yet of opinion that the high and hard ground is better than the low soft ground, on which earthquake motion is always greater than it is upon the high ground and where destruction has almost always been relatively excessive.

The Eruption of Bandaisan.

On July 15 last year telegrams were received in Tokio that at about 7.30 A.M. a terrible volcanic eruption had taken place at Bandaisan. Subsequently we learned that 595 people had been killed and 194 houses had been buried or crushed; while an area measuring 13 miles in one direction and 8 miles in another direction had been covered with boulders, earth, and mud.

I first visited Bandaisan, which is situated on the north shore of Lake Inawashiro, about 120 miles north of Tokio, in 1879. I ascended the mountain on its southern side, crossed over the summit, and descended on the north side. The top of the mountain consists of one large peak surrounded by three or four smaller peaks, one of which, called Kobandai, or Small Bandai, has been blown away. From the fact that the whole mountain was at the time of my first visit covered with trees and grass, and that its general form was not that of a typical volcano, it was some time before I was convinced that Bandaisan was really a volcano. However, from the fact that there was a tradition that in A.D. 807 the mountain had been in eruption, coupled with the facts that there were hot springs on its flanks, that such rocks as I saw were andesites, and that near the summit, beneath the grass, I observed scoriaceous rocks, evidently the outcrop of an old lava stream, I was led to describe Bandaisan as a still active volcano.

Previous to the explosion of July 15, it is said that two or three slight earthquakes were felt, one of them occurring half an hour before the violent eruption; rumbling sounds were heard, and the day before the eruption the flow of the spa near the top of Kobandaisan diminished. This latter fact was not considered of importance, as the bathers knew that the volume of water varied with the state of the weather, the quantity of water being smaller when the weather is fine, and greater when it is cloudy. In addition to this it is reported that the water in certain wells diminished in quantity, and that wild animals exhibited alarm. The water in the lake at the foot of the mountain, however, showed no change in level.

That the Bandai springs were subject to fluctuations according to the state of the weather appears to indicate that the balance between the internal forces which cause their flow and the outside atmospheric pressure were of a delicate nature. The observations respecting the behaviour of animals, of which there were many on the mountain, I myself having come upon deer in what may have been the old crater of Bandai—assuming the observations to be reliable—may be explained on the assumption that they were sensitive to slight earth-tremors, it being now fairly well established that animals like pheasants, horses, geese, &c., are certainly extremely sensitive to slight earthquake disturbances.

The eruption commenced with a violent shaking of the ground, and while the ground was moving there was a terrific explosion, followed by about twenty other explosions. The result of this explosion was to blow out one side of Kobandai, leaving a horseshoe-like cliff crater, $1\frac{1}{2}$ square miles in area; and, according to the calculation of Prof. Sekiya, to remove 1,587 million cubic yards of material, weighing 2,982 millions of tons, from the upper part of the mountain. This material, consisting of earth and rocks, some of which were 30 feet in diameter, suddenly rolled down the mountain with a velocity of about 48 miles per hour. To give

an idea of the velocity with which the débris came surging down the mountain, I may mention what happened at Nagasaka, a hamlet 7 miles distant from the site of the eruption. Ashes, or gritty mud, commenced to fall about one minute after the roar of the explosion, and the inhabitants of Nagasaka rushed from their houses to cross a valley to seek refuge on the side of a mountain only 500 yards distant. Out of 97 people who thus fled, not one of them reached the other side of the valley before they were overtaken and buried by the stream of earth and boulders, which, when it reached them, had travelled nearly 10 miles. This sea of earth and rock, which became muddy as it sopped up streams and ponds along its course, as Professor Sekiya has calculated, now covers 27 square miles of country, and spreads from its origin on the top of Kobandai in a fan-shaped form to and beyond its base, where it has blocked up the valley of the Nagasa. At the lower part of this fan-shaped mass portions of the deluge have branched out into streams, which from a distance look like the flow of lava. The bulk of the material has gone towards the north to block up the course of the river Nagasa and form marshes and small lakes, while a diverging stream has run towards the south in the direction of Lake Inawashiro. The sides of these streams are fairly perpendicular, and so well defined that you can place one foot on the wall-like edge of a stream, and the other foot on green grass. After the downpour of débris cauldron-like mud holes in the crater, which still emit roaring columns of steam, threw up vast quantities of greyish gritty mud, which was carried by the wind as far as the Pacific Ocean, 62 miles distant, and which covered a land area of about 1,000 square miles. The earthquake which accompanied the eruption, although it was very severe near Bandaisan, only extended over an area of country with a radius of about 30 miles.

A remarkable feature in this explosion was that it was accompanied by a terrible hurricane, which levelled houses and tore up trees. When I visited Bandaisan I passed through forests where most of the trees were prostrate, and all had been stripped of their leaves, and in some instances also of their bark. The appearance of these trees was suggestive of the action of some huge steam-jet which had blown over houses and trees in one direction.

Another remarkable phenomenon is a number of conical holes from two or three to 20 or 30 feet in diameter, and eight or ten feet in depth. These holes may be said to exist in thousands, and many of them are several miles distant from the crater. That they were not formed by steam is testified by the fact that, so far as I am aware, no observer observed any steam escaping from them, and the mud in them was always cold. Prof. Sekiya and other observers are of opinion that they were formed by falling stones, and the view is supported by the fact that by digging into certain of these holes boulders have been met with, and beneath these boulders the crushed remains of plants. An objection to this view is, that as large stones and small stones must have fallen from varying heights, holes ought to have been found in all stages of formation, some where stones were only partly buried, and others where the boulders had disappeared from view, while all the holes should contain one or more boulders.

The view I have advanced to explain their origin is, that they were formed by the earthquake shock packing up the watery strata, which burst to the surfaces at points of least resistance. It is certain that similar

holes have been formed at the time of almost every large earthquake; while, so far as I am aware, they have never been formed by the falling of rocks at the time of a volcanic eruption. Professor Sekiya is now engaged upon a monograph describing in detail the eruption.

The Vibrations of Locomotives, Rolling-Stock, and Structures.

At the suggestion of Mr. John MacDonald, superintendent of the locomotive department at Shinbashi, in Tokio, I was led to make experiments on the vibrations of locomotives. Owing to the violence of the motion and the actual tipping which is experienced on an engine, I found that ordinary earthquake machines were valueless, and in order to obtain an instrument suitable to record the particular class of movements, it would be necessary to make experiments. Through the kindness of Mr. Frank Trevithick, C.E., the general superintendent of the Shinbashi works, I was able to test a considerable number of contrivances, and I think I may fairly state that I have obtained an instrument which practically gives an absolute measure of the horizontal and vertical vibrational movements of locomotives. These vibrations are recorded as three components—one vertical, one longitudinal, and one transverse. Each of these components is recorded by a brass pointer writing on metallic paper covering a revolving drum. The diagrams are therefore continuous, and give a record of all the vibrations of an engine while on a given journey; and amongst other things they show the following:

1. Variations in the speed of a train, as, for instance, in ascending and descending inclines, or when approaching or leaving a station.
2. They show all the places where a train may have stopped, and the duration of the stoppage.
3. The relative extent of motions in different directions. For example, in an engine with its wheels balanced in a particular manner the longitudinal vibrations are very much greater than the transverse motions. It would seem as if the engine was exerting its power by a series of jerks. In another engine the transverse oscillations are the greater, and these, if too large, might be dangerous to the safety of the train. In fact the diagrams test the nature of the balancing of the engine.
4. From the diagrams much may be learnt about the nature of a track. The curves on the line are clearly marked, soft ground is indicated, and irregularities due to faultiness in the track are recorded.

In short, the instrument gives an automatic log of the run of a locomotive, it tests its balancing, and it records irregularities or imperfections on the line.

Although this instrument is not directly connected with seismological work, it is a useful outcome of such work, and it has given valuable suggestions as to the construction of seismographs for large earthquakes, in which there are undoubtedly quick and sudden changes in level.

Building in Earthquake Countries.

Last year, at the suggestion of his Excellency Arinori Mori, the late Minister of Education, a committee, consisting of engineers, architects, and other specialists, was called together to discuss the forms of construc-

tion best adapted to withstand earthquakes. This committee has already issued several preliminary reports, and vol. xiv. of the 'Trans. Seis. Soc.,' which is now in the press, will give to all who are interested in construction in earthquake countries a detailed account of all the material it has collected which bears upon this subject.

This material consists of observations made in Japan, Manila, Italy, and many South American countries. In Italy and Manila, at different times, the Government has issued special regulations respecting building in districts which have suffered by earthquakes.

The following pages may be taken as a summary of these observations and regulations.

In a paper upon construction in earthquake countries, read before the Institution of Civil Engineers in 1886,[1] which was republished with additions by the Seismological Society in 1887, the author suggested several broad principles which ought not to be neglected by those who had to build to withstand earthquakes. The reason that the author was led to make these suggestions was because he had observed that destruction had occurred where, if the builders had considered that the ordinary rules of construction are not altogether applicable when dealing with stresses which are applied more or less horizontally, such destruction might in great measure have been avoided.[2]

The principles suggested were as follows :

1. To select a site for a building or to give it such foundations that it receives the least possible quantity of motion. (In the following pages, *see* sections relating to Sites and Foundations.)
2. To construct in such a manner that buildings may be best able to resist stresses due to earthquake motion, these stresses being often applied more or less horizontally.

In this section the principal subjects which were referred to were unsuitability of archwork to resist horizontally applied stresses, the destruction which has so often arisen in consequence of coupling together parts of a building having different vibrational periods, as, for instance, brick chimneys and wooden houses, the ill-effects of overloading, &c. In the following pages all these matters are again referred to, but with greater detail, and at the same time much matter which is more or less new has been added.

1. *Choice of a Site.*

A good site may often be obtained in a given city by taking advantage of the results of experience. Thus in the Ansei earthquake in Tokio it was shown that the greatest destruction took place in the low soft ground, while on the high hard ground the destruction was relatively small. Observations of this nature were made in 1883 at Cassamicciola, and these were taken advantage of by the Government when laying out sites for the new town. The occasions when observations like these have been forced upon communities have been very numerous: as for example, at Lisbon in 1755, Port Royal in 1692, Belluno in 1873, in Calabria in 1783, San Francisco in 1868, Talcahuana in 1835, in Messina in 1726.

Although it is a general rule that the high ground which is hard is

[1] *Proc. Inst. C. E.*, vol. lxxxiii. Session 1885–86, Part I., paper 2108.

[2] 'On Construction in Earthquake Countries,' by John Milne, *Trans. Seis. Soc.*, vol. xii.

best, it must not be overlooked that there have been exceptional cases where buildings in such localities have suffered, as, for example, in Yokohama in 1880, and to a certain extent in Calabria in 1783.

In Tokio, as the result of our feelings, it has been shown that earthquakes are more often *felt* on the high ground than upon the low ground. Instrumental observations so far as they have gone, and the results of experience in 1855, have, however, shown that the most destructive motions have been experienced on the low ground. (*See* 'Distribution of Earthquake Motion in a small Area,' by J. Milne, 'Trans. Seis. Soc.,' vol. xiii.)

The best sites in a city may be determined, should it be thought advisable, by means of a specially organised seismic survey, which involves placing a number of similar seismographs throughout a city, and a proper comparison of the records they furnish. By doing this it has been shown that a seismic survey may be made for a small piece of ground, say one quarter square mile or less in area. Such a survey was made of the compound of the late Imperial College of Engineering, now the Gakushuin, in Tokio. The results obtained clearly showed that if we had two similar houses on that compound at a distance of less than 800 feet apart, by a given earthquake one of these houses might be destroyed, and the other suffer little, if any, damage. Until this survey was made it was not suspected that the difference in motion of two sides of that particular piece of ground could be so pronounced. Very wet ground or ground that is marshy notably forms a bad foundation. Steep-sloping ground is also bad, the alluvial materials resting on such a surface often sliding downwards, much in the same manner as tiles may slide from a steeply-pitched roof. The sliding, or tendency to slide, is in all probability aggravated when the surface is loaded by a building.

The upper edges of cliffs and scarps, where the motion of the free face of the cliff or scarp is naturally large, are also dangerous situations, and these more especially when the strata dip outwards.

2. *Foundations.*

As a result of observations made in a pit about 10 feet in depth, it was found that the motion at the bottom of the pit was in *strong* earthquakes very much smaller than it was upon the surface. These observations led to the conclusion that great advantages might be gained by giving a building a deep foundation, this advantage being increased if the building rose freely, as in a house with an open area and a basement. That at least there is no harm in such a structure is attested by the fact that in all earthquake countries where there is legislation respecting building, cellars or basement stories are recognised as admissible. That relatively but little motion enters a building with such foundations is also attested by the fact that for such cellars vaulting is allowed, whereas for stories above the ground floor it has invariably been suppressed. My own experiments in this direction gave a measurement of the relative motion above and below ground; showing that deep foundations were not simply without danger, but they might be advantageous. As, however, the experiments have only been made at one point, and as they are of so much importance to builders, it is desirable that they should be repeated.

The Ischian regulations provide that buildings should be founded on the most solid ground. If, however, the ground was soft, a platform of

masonry or cement should be formed, which for a one-story building must be ·70 m. thick, and for a two-story building 1·20 m. thick. This platform must extend from 1 to 1·50 m. beyond the base of the building. In Manila it is stipulated that the foundations must be able to bear at least twice the weight that is to be placed upon them. When the soil is bad it must be piled or consolidated by a bed of hydraulic concrete, and the foundation of a building must as far as possible be made continuous.

Another method of minimising the quantity of motion received by a building is to give it free foundations. As an example of this I may mention a room attached to my house which rests at each of its pillar-like foundations upon a layer of $\frac{1}{4}$-inch cast-iron shot placed between two iron plates. Short rollers placed at right angles might be equally effective. This building has stood for many years. It has not been disturbed by typhoons, and at the time of an earthquake a seismograph inside the building shows, relatively to outside, but little motion. Cast-iron balls or shot, even if they are only 1 inch in diameter, cannot be used. They are wanting in frictional resistance, and the building is therefore subject to movements produced by winds and other causes. I do not bring forward this building as an example to be followed in practice, but only as an illustration of a principle which may have practical applications. The first to propose the use of the ball-joint was Mr. David Stephenson, who employed it in connection with lighthouses in Japan. The form he designed was found not to be practical, and is therefore no longer used.

The ordinary Japanese dwelling-house rests loosely on the upper surface of boulders or stones planted in the soil, and therefore it is difficult to conceive how it can receive the whole of the motion imparted by the shaking ground to its stone foundations. In temples and other large buildings with heavy roofs, which are so common in the country, beneath the supporting timbers and the superstructures there is usually a multiplicity of timber joints, which at the time of an earthquake yield, and therefore do not communicate the whole of the motion from below to the parts above. In the great earthquake of Ansei, 1855, so far as I am aware, the whole of these buildings remained intact. Certain roofs which are of considerable span in the Engineering College at Toranomon in Tokio were built so that they rested freely on the supporting walls, the object being that they might remain as far as possible resting freely on the walls which moved beneath them. Although they have experienced many tolerably severe shakings, hitherto they have remained uninjured. These examples show, especially for horizontal components of motion, that if a *small* building is not firmly attached to its foundations, or that parts of a building have connections between them that readily yield, it is difficult to cause such a building to move or swing, and that by a proper application of this principle destruction may be and has been avoided.

Loose foundations might possibly be employed for *small light* buildings erected on soft ground.

For ordinary dwelling-houses, and especially for heavy structures covering a considerable area, I am inclined to the opinion that the solid continuous foundation on the hardest ground, and if possible surrounded by a free area, is the best. The objection to the loose foundations for a large building is, that different parts of the same building do not simultaneously receive momentum in the same direction, and also in large earthquakes there is an actual wave-like motion of the ground.

3. *Archwork.*

An ordinary arch is undoubtedly stable for vertically applied forces, but for horizontal stresses it is one of the most unstable structures that could be erected. Archwork has so often been the cause of ruin when shaken by an earthquake, that in Italy and Manila special rules have been drawn up respecting such structures. Thus, in Manila intersecting vaults are not allowed, and ordinary vaults are only permissible when strengthened in a particular manner by iron. In Liguria vaults can only be used in cellars, and even there the rise must be at least $\frac{1}{3}$ of the span. The law of Norcia also only permits the use of arches in cellars, and their thickness and the method of construction are defined. In Ischia archwork with a rise of $\frac{1}{3}$ of the span, and with a thickness of ·26 m. at the crown, may be used, but only in cellars.

Speaking generally, the use of archwork above ground has been prohibited, and if it has existed after an earthquake, all governments who have paid attention to building have ordered its removal. Underground its use is permitted providing that the arches are not too flat. This, however, only tells us that the motion beneath the surface is too small to destroy even a bad form of structure, and therefore such a form of structure, providing it is underground, is allowable.

In the writer's first paper on this subject, already referred to, he has given instances where archwork in Tokio has been cracked by exceedingly small earthquakes. In case of a severe earthquake it is not unlikely that much of the archwork in buildings, like the shops in the Ginza in Tokio, and in public structures, will suffer very severely. If for architectural reasons it is a necessity that arches exist, these should not be too flat; they should have a specified thickness, be protected by an iron or wooden beam, and curve into the abutments. The Ligurian regulations provide that above windows there should be two iron bars.

4. *Doors and Windows.*

In the building regulations for Norcia and Ischia it is stated that openings should be placed vertically above each other. It appears to me that if we have a series of openings like doors and windows in a wall placed vertically above each other, it is very much the same as if we had here and there built our wall with the joints of a line of bricks or stone continuously above each other—that is to say, we have destroyed the uniformity of the wall by lines of weakness which will readily give way to horizontally applied stresses.

The subject is not one of great importance, but the writer inclines to the opinion that the doors and windows in successive tiers of openings ought *not* to be above each other, but so arranged that any line of openings, when regarded vertically, is as much broken as possible.

To arrange doors and windows so that they may form ready means of escape is certainly a matter worthy of attention.

An important point mentioned in the Ischian law is the position of doors and windows relatively to the freely vibrating end of a building, the limiting distance being 1·50 metre. Similar regulations are found in the regulations for Norcia and Liguria. This distance should, if possible, be made to depend upon the materials of which a wall may be constructed, its dimensions, and the size of the openings.

5. *Chimneys.*

A very important point which constructors should keep before them is to avoid coupling together two parts of a building which have different vibrational periods, or else to couple them together so securely that they move as a whole. In Europe, the first writer who recognised the fact that builders often allowed one portion of a building to destroy another in consequence of their own synchronism in vibration was Bertelli, who mentioned the matter in 1887. The same subject has, however, in Japan been written about, experimented upon, and emphasised since 1880. In 1880 most of the wooden bungalows in Yokohama lost their brick chimneys in consequence of the wooden framing of the house swinging against them and cutting them off. One example that occurred in this year, showing that it is not necessary to give support to a solitary chimney by attaching it in any way to a building, is given by the writer in his first paper. By itself a chimney may stand, but, when partially attached to a house, the house and the chimney are mutually destructive.

The rules regulating the construction of chimneys are but few—the Ischian law states that they should be isolated from the walls; that of Liguria, that they should not be in the walls, not connected with the building, and low. Chimneys not being much required in Manila, nothing is said about them. Experience in Japan has taught householders to build their chimneys as short and thick as possible, to allow them to pass freely through the roof, and not to load them with heavy coping-stones.

After the experiences in 1879 and 1880 many of the residents in Yokohama materially altered the form of their chimneys. In 1887 these buildings did not suffer, the buildings which did suffer chiefly being those built subsequently to 1880 and without regard to the experience of previous years.

6. *Connection between different Portions of a Building.*

This leads to a consideration of the advantages to be gained by tying the different parts of a building together so that they vibrate as a whole. Since time immemorial buildings have been tied together with iron or wooden rods, but some time previous to 1868, when San Francisco was shaken, a patent known as the Foye Patent was taken out to improve the construction of sea-walls. This was made to apply to land structures, and I believe that the City Hall and other buildings in San Francisco are built upon this plan, which consists in tying together the walls at each floor by transverse and fore and aft rods of steel or iron. A plan similar to this is that of Mr. J. Lescasse,[1] described in this volume. It has been applied to several buildings in Tokio and Yokohama.

For such earthquakes as these buildings have experienced, excepting on one occasion when the chimneys of the German Hospital in Yokohama were more or less destroyed, they have stood well. This system, however, requires to be thoroughly executed; for if the rods be too few, or if the bearing surfaces be too small, rather than supporting a building they accelerate destruction, especially at points of contact. Such build-

[1] *Mémoires de la Société des Ingénieurs Civils*, 1887, p. 212.

ings, partly for this reason, and partly on account of their expense, are not looked upon with great favour in Italy. The Ischian law specifies that if iron bands or chains are used they must act upon a large surface.

7. *Roofs.*

The advantage to be gained by making the upper portions of any structure light is very great. When a building with a heavy roof is suddenly moved forwards, the roof by its inertia tends to remain at rest. The result of this is the tendency to cause a fracture between the lower part, which has been removed quickly and the upper part, which has tended to remain at rest. In building regulations special reference is made to roofs, which must always be light, the material recommended being iron, zinc, or felt, ordinary tiles being only permissible for buildings which are only one story high and not habitations. Certain kinds of tiles have sometimes been regarded as permissible, but these require to be properly secured, and it is specified that in such cases, above the ceiling, there shall be a floor of planks. Tiles require to be especially well fastened near the eaves.

The difficulty with roofs made of sheet metal is first to secure them so that they shall not be disturbed during severe gales, and, second, to protect the interior of the houses from heat. In Manila the first end is accomplished by a special system of bolting, whilst the latter is attained by a series of false ceilings.

The tie beams of trusses should extend at least two-thirds across the thickness of the wall, if not over the whole thickness, and these rest upon wall-plates. The form of truss recommended in Manila is the one with a central post (king-post). For spaces greater than 7 metres, iron should be used, and trusses must be so placed that they do not act upon weak points in the walls.

The Ischian law does not prohibit the use of flat roofs (*terrazzo*), but it provides that the framing of the same shall be strong, and covered with materials which are fairly light.

The Commission who reported to the Government, however, condemned such roofs.

8. *Walls.*

Walls, like chimneys, require to be light and strong. If heavy, and especially if loaded in their upper parts by copings and balustrades, they may be fractured and shattered by their own inertia. The height to which walls may be taken with safety depends upon the material of which they are constructed, the nature of the roof, &c. In Ischia it was suggested to limit buildings to two stories, or a height of 7·55 metres. The regulations, however, give 10 metres as a limiting height, and, if they must be of simple masonry of tuff, to a height of 4 metres, with a thickness of ·70 metre. The committee suggested that external walls should be at least ·30 metre in thickness, and that their uniformity should in no way be broken by openings for chimneys, pipes, &c.

The Ligurian regulations allowed three stories above the cellar, and a height of 15 metres. The walls should be thick. If not built on the barrack system they should be at least 60 centimetres and have a batter of $\frac{1}{20}$ of their height. The Norcian regulations allowed two stories

above the cellar, and a height of 8·5 metres. If a third story existed it was to be destroyed.

Other suggestions were made respecting the thickness of walls, which were to be thicker than those ordinarily used, and their thickness was to vary with the material employed and the height of the structure.

In Manila masonry walls of ordinary dwellings only reach the first story, the upper story being of timber. The walls for public buildings, however, may be higher. The length of a wall should not exceed twice its height unless it is supported by a buttress. Buttresses might be used at intervals not greater than twice the height of a wall. Its thickness must be one-fifth of its height. Outside walls, transverse walls, and buttresses must be well united, while the corners of buildings should be supported by internal or external buttresses.

It would appear that the system of building with an upper story of wood resting on and not built into the supporting wall, and a light roof, ought to do much towards insuring the stability of a building. A plan by which the weight of ordinary masonry may be reduced is to use hollow bricks.

In Manila the regulations specify that upper walls must not rest on a floor.

9. *Balconies and Cornices.*

In Ischia it was suggested that balconies should not project more than ·60 metre beyond the wall, and should be so constructed that they formed a part of the wall.

The regulations provide that cornices should not project more than ·30 metre beyond a wall.

The Ligurian regulations provide that cornices shall not project beyond the thickness of the wall to which they are attached. Roofs may not rest on cornices. Stone consols must run through the wall to which they are attached. In Manila the regulations require that the balconies rest in the prolongation of timbers of the upper floor. Otherwise a special form of construction is required.

From what I saw of the balconies or upper verandahs when in Manila, it appeared that many of them were without support on their outer sides. In such instances they act as loaded cantilevers, which, either for horizontal or vertical motions of the building, must cause considerable stress at their points of junction with the supporting wall. A careful examination of several hundreds of brick houses in Tokio showed that the walls were usually cracked at the points where they were entered by the beams supporting a balcony, notwithstanding the fact that the same balconies were supported along their outer face by vertical pillars rising from the ground. My own opinion is that balconies in any form are objectionable features in a building constructed to withstand earthquakes.

10. *Shape and Orientation of Buildings.*

In Liguria and Ischia the regulations provide that a building shall be rectangular in plan, and as nearly as possible square. Churches should be small and of the basilic form, with three naves, and iron columns between the naves. The Norcian regulations also recommend a square form.

In Ischia it was suggested that buildings be placed so that the direction of the principal motion they were likely to receive was along the

diagonal of their plan. A result like this might be obtained by laying out the streets and roads in proper directions. Rossi suggested that the most resistant sides of buildings should be placed at right angles to the nearest line of volcanic fracture, he holding the opinion that earthquake vibrations were propagated normally from the lips of such fractures.

The suggestion that buildings should have a rectangular plan or be simple in form is a suggestion worthy of consideration, for it would certainly seem that such a building would be subject to less destructive stresses than one which was largely built up of wings and other projecting parts, no two of which could be expected to vibrate in unison.

As to whether any great good may be gained by giving a building a proper orientation is not certain. In Tokio it appears that walls running in certain directions have been cracked more than others, and also that at the time of great earthquakes there has been more destruction in streets running in particular directions. Streets ought certainly to be wide, inasmuch as they would then form a refuge from falling débris.

11. *Floors.*

In Ischia it was suggested that floor-joists should rest with their whole thickness on the walls. If possible, joists should cross each other at right angles, and the floor-planking be laid diagonally.

Bertelli proposes a system of flooring of iron beams connected by brick vaulting, or in place of this ordinary joists and planking. The beams on one story should be placed at right angles to those on another. In all cases the joists are to extend completely through a wall. This regulation is also contained in the Norcian edict.

From these notes it appears that the intention of the authors of the regulations has been to utilise the floors to bind the building together as a rigid whole, and allow joists to extend so far into walls that there is no danger of their being drawn from their supports.

12. *Ceilings.*

Ceilings should be made in the ordinary manner with laths and plaster. But heavy ornamentation should be avoided.

13. *Staircases.*

Although staircases, if they are heavy, might prove a danger to walls, their construction has not been regulated by legislation. Bertelli suggests that they should be constructed of pieces bedded in the walls, as in the Tuscan system. If made by vaulting they are dangerous.

14. *Materials.*

In all regulations special stress is laid on the quality of materials employed, and in all cases it is specified that these should be of good quality. The Ischian regulations specify that for the principal frameworks of building chestnut must be used. In all cases square stone is to be employed. The lime must be good, and be properly slaked with fresh water. Below ground hydraulic mortar must be used, and the sand used in making mortar must be clean. These matters are treated upon in all regulations. In the regulations for Manila we find special remarks

condemning the use of liquid lime, and recommending that stone walls should be kept wet while mortar is setting, that there should be good bonding, &c.

15. *Types of Buildings.*

The type of building most suitable for earthquake countries was discussed at considerable length by the Commission summoned after the disaster in Ischia.

The objections to iron buildings chiefly rested in their cost, the difficulty of keeping them cool, and the fact that as they were a novelty it might be difficult to get them generally accepted. The Commission, however, considered them durable and secure, and recommended that experimental buildings should be erected.

Timber buildings, although sufficiently strong and elastic to resist earthquake motion, and at the same time impervious to heat, have the objection that they are not durable, and are subject to fire. These objections may to some extent be overcome by the proper application of paints and chemical preservatives. Mixed constructions of iron and timber were not considered to present great advantages over those wholly made of timber. Buildings may be made of iron or masonry either by covering an iron framework with stone or brick, by building an iron framework inside the masonry walls, or by filling up the spaces between a double metallic framework with hollow bricks or other materials. Such buildings, although exceedingly good from many points of view, have the drawback that they are exceedingly expensive.

Having considered these types, from which it will be observed ordinary buildings of brick and masonry have been excluded, the committee describe a 'barrack system' of building, which is the system they particularly recommend for Ischia. Briefly, such a building consists of a timber framework well braced together, the spaces between the timbers being filled up with hollow bricks or some light material like scoria. The timbering is hidden by rough cast. After the disaster in 1755 such a system was made compulsory in Portugal. A building of this type, which may be made ornamental with an outside covering of tiles, is cheap, impervious to heat, and safe against earthquakes and fires. This suggestion respecting the system of construction was adopted in the regulations issued by the Government.

In the building regulations for Norcia the barrack system is the one to which preference is given. In the Manila regulations considerable latitude is allowed as to the system of construction. Stone walls are considered best, but concrete or brick are also considered good. Although timber offers great resistance to earthquakes, its destructibility by fire, white ants, ordinary rot, and its inability to exclude heat prevent its recommendation. An iron framework filled in with concrete is spoken of with favour. In the recommendations of a committee appointed to consider building in Manila, we find that stone is recommended for the basement and for the walls of the ground floor. This, with an upper story of timber, is the type of building which is common in Manila.

The military committee which was summoned in connection with the destruction in Manila in 1863 pointed out that destruction had occurred in all classes of buildings, but buildings with masonry supports had suffered more than others. This led them to suggest that only one kind of material should be used in constructions, and masonry supports should be

avoided. Private buildings should be of wood. In all cases the limiting spans of roofs were specified, and the roofs must be light. Lieut.-Colonel Cortés, who wrote at some length on structures in earthquake countries, shows that buildings must be light as well as strong, and this may be obtained by building their parts together much in the same manner that the timbers of a ship are bound together. Foundations and walls should be continuous. Timberwork and masonry should not come in contact, otherwise they may be mutually destructive.

After criticising the system of building in Manila, and showing how it may be improved, especially with regard to balconies and roofs, Colonel Cortés proposes as a foundation a timber platform almost in the surface of the ground, from which rises a building with iron or timber framing footed on a dado of masonry, surmounted by a light roof. The wall framing may be filled with brick or plaster. Colonel Cortés' descriptions are accompanied by an elaborate series of illustrations.

The Californian system of construction, for which a patent has been granted, appears to be very similar to that proposed by Mr. Lescasse, the essential feature in which is to tie a masonry construction together at each story by a set of iron or steel rods, which run from end to end, and from back to front in the interior of the walls of a building. There are also rods running vertically.

From South America but little information has been obtained. In Columbia the smaller houses have been built of thick adobe bricks, while the Spanish have used stone.

In Equador (Quito) occasionally a special earthquake-proof room is built, the walls of which are a wooden framework filled in with adobe. Many houses which have adobe walls three feet thick have only one story, and there are few houses with more than one upper story.

In Venezuela, also, the houses are low. In Mexico and Bolivia the houses are solidly built; while in Lima certain buildings are constructed lightly so that they may yield.

From Guatemala (San Salvador) I received from Messrs. Clark & Co., contractors, the drawing of a house supposed to be earthquake-proof. It is of timber well framed together, and very similar to the bungalows in Japan.

These latter descriptions are particularly meagre, and for a full description of the system to which they allude it is necessary to refer to vol. xiv. of the 'Trans. Seis. Soc.' of Japan.

16. *Conclusions.*

If we wish to mitigate the effects of earthquakes, one general conclusion that may be drawn from what has been written is, that it is essential to select a site where we know from experience and from experiment that the ground suffers but slight motion. This will generally be the hard ground, which is usually the high ground. Soft ground, slopes, and scarps should be avoided.

Having obtained our site, we can follow one of two general systems of construction—either to give so much rigidity to a structure that it may be likened to a steel box, or to erect a building which is light, but which has so much flexibility that it may be compared to a wicker basket—in either of these structures we ought to have lightness, especially in their upper parts.

Amongst the former class of buildings, which, from the materials of

which they are constructed, are unquestionably heavy, we have ordinary structures of stone or brick (by preference we might use hollow bricks). These should rise from a deep foundation, have a free basement, walls of unusual thickness, and be well bonded and tied together. The roofs should be light, and the precautions respecting the position and form of openings, the arrangement of floors, roof trusses, and top weight referred to in the preceding epitome carefully attended to. In this case we have a building where its strength more than outweighs the ill-effects due to its weight. Such buildings are durable, and relatively safe against fire; they are suitable for all climates, but they are relatively to all other buildings very expensive.

For this latter reason this type of structure can only be employed for buildings of importance.

Amongst the light buildings which have sufficient strength and flexibility to overcome effects due to their own inertia when shaken by an earthquake are nearly all well-constructed structures of wood or iron. The former of these, however, is neither durable, safe against fire, nor impervious to heat and cold. These objections may, however, be practically overcome, and wooden buildings are cheap. Iron buildings are relatively expensive, and without special arrangements they are too hot in summer, and too cold in winter.

A type of building which offers the same advantages as a brick or stone structure does in relation to the danger of fire, and in being suitable for changes in temperature, but which is very much cheaper, and at the same time safe against all ordinary earthquakes, is a building constructed on the barrack system, so strongly recommended in Italy. The framing may be of wood or iron, while the filling-in material which forms the walls, which ought to be as light as possible, may consist of hollow bricks or a concrete of light material. For this latter purpose in Japan experiments might be made with a concrete made of the pumicious light scoria of which in Japan there is such an abundance. I would also call attention to the possible employment of cylindrically-formed or drainpipe-shaped bricks, such forms being stronger than bricks of the ordinary rectangular section.

In all these buildings, whether they be of masonry, iron, wood, or built according to the barrack system, the roofs must be light, openings must be in proper positions, walls must be of moderate height, while floors, trusses, balconies, and the like must be constructed in accordance with the suggestion contained in the previous epitome. Ordinary structures in bricks or stone are usually bad, while timber structures with a masonry front are worse. To resist earthquake motion we require lightness, strength, and, if possible, a certain elasticity. Weight, unless it is accompanied by great strength, should be avoided.

For buildings of importance I suggest the use of brick. Let the buildings be placed in good situations, the brickwork well bonded and unusually thick, and let it rise from deep foundations. Roofs should be light. For ordinary buildings, unless the barrack system be adopted, I suggest that for a country like Japan ordinary frame buildings continue to be used. To improve them they require more diagonal bracing, lighter roofs, and some protecting covering against fire. In carrying out these suggestions, the conclusions respecting general principles and details of construction arrived at in the preceding epitome must not be overlooked.

Report of the Committee, consisting of the Hon. RALPH ABERCROMBY (*Chairman*), Professor CRUM BROWN, Mr. MILNE-HOME, Dr. JOHN MURRAY, Lord McLAREN, *and* Dr. ALEXANDER BUCHAN, *appointed for the purpose of co-operating with the Scottish Meteorological Society in making Meteorological Observations on Ben Nevis.*

THE work of carrying on the observations hourly, by night as well as day, has been carried on by Mr. Omond and his assistants during the year with the same enthusiasm and unbroken continuity as in time past; and the five daily observations in connection with the Ben Nevis Observatory have been made at Fort William by Mr. Livingston with the greatest regularity and care.

As in the previous year, the state of the health of the observers, occasioned by their continuous residence at the top of the mountain, where exercise in the open air is practically impossible during the greater part of the year, rendered it again necessary to give them relief during the winter and spring. The services of Mr. Drysdale were again secured for six months; Mr. R. C. Mossman, the Society's observer for Edinburgh, gave his services as observer for six weeks in April and May; and Messrs. R. Turnbull and J. McDonald, Edinburgh, have given a month's service each as observers in July, August, and September of this year. Messrs. Omond and Rankin, during the time they were relieved from the work of the Observatory, took part in the work of the office of the Scottish Meteorology Society, and gave material assistance, more particularly in the reduction, preparation for press, and discussion of the Ben Nevis observations.

The photographing of clouds and other meteorological phenomena has been actively prosecuted at the Observatory, and results of considerable interest and importance have been already obtained. Selections from the photographs were exhibited by the Scottish Meteorological Society and by the Royal Meteorological Society during the winter session. Of these photographs four are submitted with this Report—viz., 1, a photograph of St. Elmo's fire; 2, a cloud photographed at midnight of June last year; 3, a remarkably fine photograph of a cloud, partly made up of flattened masses, which is occasionally formed in mountainous districts; and 4, photographs of crystals on the Observatory and instruments outside.

Mr. Rankin has extended and amplified his investigation of the cases of St. Elmo's fire recorded at the Observatory, and the results, which are interesting and suggestive, have been published in the 'Journ. Scot. Meteor. Soc.'

Mr. Omond has entered on an investigation of the relations of the wind direction on the top of Ben Nevis to the sea-level isobaric of the district at the time, and to the storms advancing on the Atlantic towards North-Western Europe, as shown on the daily weather charts of the northern hemisphere published by the Meteorological Institutes of Germany and Denmark.

This is properly only the commencement of a large discussion of the Ben Nevis observations, in some of their more practical aspects, which will be undertaken and pushed forward next year on the plan referred to

in last year's Report, as rapidly as the means at the disposal of the Directors of the Observatory will admit.

This season (1889) the snow disappeared from the summit of the mountain in the middle of May, being about a month earlier than in any previous year, and seven weeks earlier than in 1885; and during the month of June the spring near the Observatory, and about 60 feet lower down, frequently ran dry, so that for some time water had to be carried on horseback a distance of two and a half miles.

The Directors have had under consideration a proposed systematic observation of the numbers of dust particles in the atmosphere with the instrument recently invented by Mr. John Aitken, and they are of opinion that the Ben Nevis Observatory is the best place for making the observations in the most satisfactory manner. Mr. Aitken will himself superintend the construction of the two instruments which are required, and will see to the placing of the stationary one in the Observatory, and its connections with the atmosphere outside, in suitable positions, and give directions as to the portable one designed as a check instrument, and for observations made at various distances from the Observatory. Application has been made for a grant from the Government Research Fund to aid in carrying on this novel and important research.

Mr. Aitken recently visited the Observatory, and ten observations of the numbers of dust particles on the top of the mountain were made by Mr. Omond and himself, with the result that the numbers per cubic centimetre rose from 350 at noon to 500 at 3 P.M. This result of the first observation is interesting and suggestive. The purest air previously obtained by Mr. Aitken anywhere was on the Ayrshire coast, and on that occasion the numbers were 1,260 per cubic centimetre. It may be also observed that the numbers on Ben Nevis rose from noon to 3 P.M., the observations being made at the time of the day when aerial currents from lower levels ascend along the heated sides of the mountain to the Observatory.

In January last the Directors accepted an offer from the Meteorological Council that on being satisfied that provision had been made for the maintenance of a Low Level Observatory at Fort William, they would supply and erect in the Observatory the self-registering instruments and otherwise complete the ordinary outfit of meteorological instruments, and make an annual grant of 250*l.* towards its maintenance, and also continue the grant of 100*l.* yearly under the present arrangement.

Since last Report, the Directors have received a legacy of 500*l.*, bequeathed to the Observatory, by the late R. M. Smith, Esq., who was one of the directors; and a grant of 1,000*l.* from the Association of the Edinburgh International Exhibition of 1886 from the Surplus Fund of the Exhibition. A suitable site for the Low Level Observatory was procured in Fort William, and plans of the buildings were prepared by their architects, Messrs. Sydney Mitchell and Wilson, which were submitted to the directors and the Meteorological Council and approved of. The building is now well advanced, and it is expected that the Observatory will be opened towards the end of the autumn.

The Directors of the Observatory and your Committee in their successive Reports from 1881 insisted on the absolute necessity of combining the double observation for all forecasting purposes, and inquiries in connection therewith; in other words, of combining with the observation at the top of Ben Nevis that made at the same instant near sea-level

at Fort William. Having hitherto only had five observations a day from the Low Level Station, it was of course impossible to investigate the progressive changes of the vertical gradients from hour to hour, and consequently also impossible to turn the observations of the Ben Nevis Observatory to their proper account in forecasting weather. With the opening of the Low Level Observatory will commence a new era in the work of the Ben Nevis Observatory. It will then be possible by the double set of horizontal meteorological gradients and vertical meteorological gradients thus obtainable to examine more fully and rigorously the atmospheric changes which precede, accompany, and follow the passage across these islands of the cyclones and anticyclones of North-Western Europe.

For the year 1888 the following were the monthly mean pressures and temperatures, the amounts of the rainfall, and the hours of sunshine, the pressures at Fort William being reduced to 32° and sea-level, those of the Ben Nevis Observatory to 32° only:—

Table of Means, 1888, Ben Nevis Observatory and Fort William.

—	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
						Mean Pressure in Inches.							
Ben Nevis Observatory	25·467	25·391	25·035	25·271	25·359	25·453	25·265	25·378	25·590	25·367	25·069	25·182	25·319
Fort William	30·104	30·078	29·660	29·880	29·925	29·962	29·740	29·881	30·132	29·915	29·636	29·754	29·889
Difference	4·637	4·687	4·625	4·609	4·566	4·509	4·475	4·503	4·542	4·548	4·567	4·572	4·570
						Mean Temperature.							
Ben Nevis Observatory	28°·8	20°·8	20°·8	25°·5	32°·2	39°·6	38°·9	38°·8	39°·2	33°·6	27°·3	28°·2	31°·1
Fort William	39·0	35·6	36·6	43·0	49·3	55·4	54·5	54·7	51·3	48·1	44·4	42·8	46·2
Difference	10·2	14·8	15·8	17·5	17·1	15·8	15·6	15·9	12·1	14·5	17·1	14·6	15·1
						Rainfall in Inches.							
Ben Nevis Observatory	16·03	8·79	7·45	6·89	12·87	3·76	7·82	12·37	6·90	17·21	20·60	11·77	132·46
Days of no Rain	12	11	13	10	11	16	4	5	16	3	10	7	118
Fort William	9·36	3·06	5·33	4·03	6·39	2·52	4·35	7·19	2·71	7·12	11·08	7·09	70·23
				Hours of Sunshine to nearest Whole Hours at Ben Nevis Observatory.									
No. of Hours	70	73	64	68	126	250	69	72	121	28	8	21	970
Possible Hours	231	275	365	426	508	529	528	467	381	319	242	210	4,470
						Maximum Temperature.							
Ben Nevis Observatory	48°·3	35°·6	34°·2	35°·5	49°·9	61°·1	54°·4	47°·1	57°·6	51°·9	39°·0	41°·3	61°·1
Fort William	51·9	50·7	49·7	57·5	74·8	85·8	75·8	69·8	70·1	63·8	58·7	55·6	85·8
						Minimum Temperature.							
Ben Nevis Observatory	9°·6	10°·1	7°·2	14°·2	19°·2	23°·5	26°·2	29°·6	21°·3	16°·2	18°·3	16°·6	7°·2
Fort William	17·7	11·7	21·2	26·2	32·2	35·2	38·3	36·2	33·2	31·2	28·2	22·0	11·7

At Fort William the mean annual temperature was 46°·2, being the same as last year, which was a degree under the average. The mean at the Observatory was also the same as on the previous year. In no month did the mean temperature at the Observatory rise to 40°·0, the highest being 39°·6 in June; and it is remarkable that this and three subsequent

months did not differ quite a degree from each other. On the other hand, in 1887 the means of the three summer months were 45°·4, 41°·3, and 40°·0. The means for February and March were 3°·0 below the averages of these months. The mean for January was 5°·2 above the average. It is remarkable that in this month the difference between the means of the High and the Low Level stations was only 10°·2, and the difference for September was only 12°·1, these being exceptionally small differences for the difference of height. In April the difference was 17°·5. The sea-level pressures at the Observatory and at Fort William were, respectively, 30·094 inches and 30·104 inches in January, and 29·865 inches and 29·880 in April. Thus in each case the sea-level pressures closely agree, showing that these anomalous temperatures were not confined to the surface of the earth.

The minimum temperature on Ben Nevis for the year was 7° 2 being the lowest yet observed since the Observatory was opened in 1883. The maximum was 61°·1 in June, which closely agrees with the maxima of previous years, except that of 1887, which rose to 67°·0. It is also to be noted that so late as September, temperature rose to 58°·8 on the 23rd of the month.

The registrations of the sunshine recorder showed 970 hours of sunshine during the year, the smallest number of hours for any month being 8 for November, and the largest 250 in June, being nearly half the possible sunshine. The number of hours for the four years now observed, beginning with 1885, were 680, 576, 898, and 970. The contrast of the sunshine of 1886 with that of 1888 is thus very striking.

The amount of the rainfall for the year was 132·46 inches, the month of least rainfall, 3·76 inches, being June, and of greatest, 20·60 inches, being November. The number of days on which precipitation was *nil*, or less than the hundredth of an inch, was 118. The number of rainless days for the three last years have been 159, 128, and 118. From all the observations yet made, it is seen that a fall, equalling at least 1·00 a day, has occurred on an average of one day in nine.

Atmospheric pressure was this year again above the annual average, the mean at sea-level being 29,889, or 0·055 higher. The lowest mean at the Observatory, 25·035 inches, occurred in March, and the highest, 25·590 inches, in September; the difference being 0·555 inch. At sea-level at Fort William the extreme monthly means were 29·636 inches in November, and 30·132 in September; the difference being 0·496 inch.

Third Report of the Committee, consisting of Sir JOHN LUBBOCK, Dr. JOHN EVANS, Professor W. BOYD DAWKINS, Dr. R. MUNRO, Mr. W. PENGELLY, Dr. HENRY HICKS, Professor MELDOLA, Dr. MUIRHEAD, *and* Mr. JAMES W. DAVIS, *appointed for the purpose of ascertaining and recording the localities in the British Islands in which evidences of the existence of Prehistoric Inhabitants of the country are found.* (*Drawn up by* Mr. JAMES W. DAVIS.)

YOUR Committee desire to draw attention to the previous reports presented at the meetings of the Association in the years 1887–8, in which the objects sought to be attained by the Committee are given in detail; and

the distinctive signs are indicated, which have been adopted by the Committee, for the purpose of recording the position and character of prehistoric finds on the one-inch survey map.

The following list of camps and other objects have been recorded on maps of Herefordshire and Worcestershire by Henry Wilson, Esq., M.A., of Malvern Link:—

HEREFORDSHIRE.

Camps.

Thornbury, near Bromyard.
Brandon.
Coxwall.
Dinedor.
Aconbury.
Much Dewchurch.
Marden.
Wall Hills, near Ledbury.
Hereford Beacon, near Malvern.
Holly Bush Hill, near Malvern.
Ivington, near Leominster.
Risbury.
Croft Ambrey.
Aymestry.
Gaer, near Pandy.
Dormington, near Hereford.
Sollershope.
Ganarew.
Puddlestone.
Kilbury.
Arthurstone Dolmen, near Dorstone.
Cave on Hereford Beacon.
Sacrificial stone (so called) on Hereford Beacon.
British villages on Hereford Beacon and Hollybush.
Offa's Dyke.

Plans of most, if not all, of the above remains are published in the archives of the Woolhope Field-club.

WORCESTERSHIRE.

Camps on Woodbury Hill, near Martley.
Camp on Barrow Hills, near Martley.
Camp on Eldersfield.
King and Queen stones on Bredon Hill.
Camp on Dripshill (? Roman), near the Rhydd.

The Prehistoric remains preserved in the counties of Antrim and Down have been recorded on the 1-inch Ordnance survey map. The following is a list of them, prepared by William Gray, Esq., of Belfast:—

Catalogue of the Ancient Monuments and Prehistoric Settlements of the Counties Antrim and Down, Ireland, inserted on the One-inch Ordnance-map by Mr. William Gray, of Belfast.

For fuller particulars reference may be made to the following works:—

'Transactions of the Royal Irish Academy.'

'Journal of the Royal Historical and Archæological Association of Ireland.'

'Belfast Naturalist Field Club's Guide to the North of Ireland,' and Appendix for the year 1883–4.

'Ulster Journal of Archæology.'

O'Laverty's 'Down and Connor.'

Co. Antrim.

*Settlements or Camps, showing their distribution and the objects of stone or flint found at them.**

[R, rare; F, few; C, common; VC, very common.]

—	Flint flakes	Worked flakes	Scrapers	Cores	Hammers	Rough flint Celts	Polished flint Celts	Pottery	Arrow Heads	Stone Celts
[1] Portrush $7\frac{9}{5}$	C	F	C	F	—	—	—	—	—	—
[1] Bushfoot $7\frac{8}{10}$	C	—	F	F	—	—	—	F	—	—
[1] Whitepark Bay $7\frac{7}{5}$	VC	C	VC	C	VC	F	—	VC	F	—
Rathlan Island $8\frac{5}{2}$	—	—	—	—	—	—	—	—	—	VC
Portaleen Bay $8\frac{10}{10}$	VC	—	F	F	—	—	—	—	—	—
Mount Sandel $13\frac{3}{5}$	VC	C	C	C	F	VC	—	F	—	—
Caranure $14\frac{7}{13}$	VC	—	F	F	—	—	—	—	—	—
Garron Point $14\frac{8}{14}$	C	F	F	—	—	—	—	—	—	—
[2] Carnlough $14\frac{11}{13}$	VC	C	F	C	F	F	—	—	—	—
Straidkelly $14\frac{12}{14}$	VC	F	—	—	—	—	—	—	—	—
Madman's Window $20\frac{1}{16}$	C	F	F	C	C	—	—	F	—	—
[2] Ballygally $21\frac{5}{1}$	VC	F	F	C	—	F	—	—	—	—
[2] Larne $21\frac{9}{3}$	VC	C	F	C	R	F	—	—	—	—
[2] Glynn $21\frac{10}{3}$	VC	F	—	C	—	—	—	—	—	—
Toome Bridge $27\frac{4}{13}$	VC	VC	C	F	—	F	—	—	F	VC
[2] Whitehead $29\frac{3}{7}$	C	R	R	F	—	—	—	—	—	—
[2] Kilroot $29\frac{5}{5}$	VC	C	F	C	—	F	—	—	—	—
Missvale $36\frac{7}{2}$	VC	F	F	F	F	—	—	—	—	C
Lough Neagh $36\frac{9}{1}$	C	F	—	F	—	—	—	—	—	—
Ormean $36\frac{17}{2}$	VC	C	C	C	F	F	R	—	F	F

[1] Sand dunes. [2] Raised beach gravels.

Cromlechs.

Cloughnabogill, $7\frac{7}{15}$
Glegnagh, $7\frac{8}{15}$
Mount Druid, $7\frac{7}{16}$
Cloughamucher, $8\frac{11}{9}$
„ No. 2—$8\frac{11}{9}$
Broadstone, $13\frac{11}{12}$

Broadstone, $13\frac{11}{12}$
Cloughs, $13\frac{5}{9}$
Ticloy, $20\frac{3}{10}$
Ballygilbert, $20\frac{4}{17}$
Island Magee, $21\frac{9}{5}$

Menhirs or Standing-stones.

Hungry House, $8\frac{11}{9}$

Holestone, $28\frac{4}{11}$

Stone Circles.

Tow Head, $8\frac{9}{9}$.—A group of stones about 3 feet high, forming a circle of about 60 feet diameter.

Dunadry, $28\frac{7}{5}$.—Composed of 47 stones about 6 feet high, enclosing a space 66 feet in diameter.

Tumuli.

Carnamore, $8\frac{10}{9}$

Doonan, $20\frac{2}{13}$

* The figures at the end of the names in each case denote the position of the monum nt or s te on the one-inch Ordnance Map. Thus 'Portrush $7\frac{9}{5}$' indicates that Portrush is on sheet No. 7, and the site referred to is 9 in. from the top of map and 5 in. fro n the left side, or, in other words, the site is 9 in. south and 5 in. east.

Ancient Burial Places.

Gig-ma-gogs grave, $7\frac{10}{7}$
Ossian's grave, $14\frac{5}{9}$
Madman's Window, $20\frac{1}{16}$
Doonan, $20\frac{2}{13}$
Ballygilbert, $20\frac{3}{17}$
Ballyboley, $20\frac{11}{16}$
Rough Fort, $28\frac{8}{13}$

Cashels.

Tomamoney, $8\frac{12}{11}$
" $8\frac{12}{11}$
Cashel, $20\frac{5}{10}$

Caves.

Ballintry,[1] $7\frac{7}{6}$
Ballyholme, $7\frac{10}{7}$
Kurckertoiton, $7\frac{10}{7}$
Dunseverick,[2] $7\frac{7}{12}$
Goban Saer's Castle,[2] $8\frac{4}{10}$
Tomamoney, $8\frac{12}{11}$
Cave Hill,[2] $13\frac{1}{5}$
Moyaver,[2] $13\frac{18}{2}$
Mount Davis, $19\frac{7}{17}$
Connor,[2] $19\frac{12}{5}$
Wiley's Fort, $28\frac{4}{16}$

Co. Down.

Cromlechs.

The Giant's Ring, $36\frac{6}{16}$
Mount Stewart, $37\frac{6}{14}$
The Kempstone, $37\frac{2}{6}$
Laganny, $48\frac{9}{13}$
Loughanisland, $49\frac{8}{4}$
Slievenagriddle, $49\frac{8}{11}$
Loughmoney, $49\frac{9}{11}$
Cloughmore, $60\frac{5}{11}$
Sliddery Ford, $61\frac{3}{2}$
Causeway Water, $71\frac{3}{10}$
Cratee Stone, $71\frac{3}{5}$

Settlements or Camps, showing their Distribution and the objects of stone or flint found at them.

[R, rare; F, few; C, common; VC, very common.]

—	Flint Flakes	Worked Flakes	Scrapers	Cores	Hammers	Rough Flint Celts	Polished Flint Celts	Pottery	Arrow Heads	Stone Celts
[1] The Kinnagar, $29\frac{11}{2}$	VC	C	F	C	—	F	—	—	—	—
[1] Holywood Beach, $29\frac{11}{3}$	VC	C	F	C	—	F	—	—	—	—
[1] Ballyholme, $29\frac{9}{10}$	VC	C	F	C	—	—	—	—	—	—
Annadale, $36\frac{4}{17}$	C	C	F	F	—	—	—	—	—	—
Reagh Island, $37\frac{8}{10}$	C	—	—	—	—	—	—	—	—	—
Ballydock, $49\frac{7}{15}$	C	F	—	—	—	—	—	—	—	—
[2] Dundrum, $61\frac{3}{3}$	VC	F	C	C	C	—	—	C	F	F
Leestone, $71\frac{3}{17}$	VC	—	—	C	—	—	—	—	—	—
[2] Cranfield, $71\frac{6}{12}$	C	—	F	F	—	—	—	—	R	—

[1] Raised beaches. [2] Sand dunes.

Menhirs.

Donaghadee, $29\frac{10}{14}$
Ballyhalbert, $37\frac{8}{18}$
Loughbrickland, $48\frac{10}{3}$
Slidderyford, $61\frac{3}{2}$
Toberbank, $71\frac{1}{11}$

[1] The cave at Ballintry is a natural ossiferous cavern.—*Ulster Journal of Archæology.*

[2] These are artificial caves or souterrains, not now connected with raths or forts. All the caves unnumbered are artificial chambers connected with ancient raths or forts.

Stone Circles.

Ballyartin, 49$\frac{8}{11}$.—This circle, 43 feet in diameter, is indicated by only 8 stones about 4 feet high, and there is an avenue formed of stones 7 to 8 feet long.

Ballynoe, 49$\frac{11}{8}$.—This is a double circle: the inner circle 19 yards in diameter, formed of 22 stones, and the outer 35 yards in diameter, formed of 49 stones; several of the stones are 7 feet high.

Mellin Bay, 49$\frac{3}{17}$.—This is a small circle on the bank near the shore, and is composed of stones $1\frac{1}{2}$ or 2 feet over the surface.

Tumuli.

Deehommed, 48$\frac{10}{11}$	Causeway Water, 71$\frac{3}{10}$

Ancient Burial Places.

Ballygoney, 49$\frac{3}{1}$	Killowen, 71$\frac{2}{8}$
Slievenagriddle, 49$\frac{8}{11}$	Kilkeel, 71$\frac{3}{14}$

Cashels.

Drumgooland, 48$\frac{10}{11}$	Ballynahinch, 48$\frac{3}{17}$
" 48$\frac{10}{11}$	

Caves.

Craigarad, 29$\frac{11}{4}$	Ballee, 49$\frac{11}{11}$
Cloghy, 49$\frac{17}{3}$	Arbor, 49$\frac{12}{13}$

All are artificial chambers connected with ancient raths or forts.

Crannoges.

Fair Head, 8$\frac{8}{7}$	Loughmourne, 29$\frac{3}{3}$
Loughravel, 27$\frac{5}{17}$	

Other lists and records are in progress, and will be presented as early as possible. Meanwhile, it is requested that members of the Association, the secretaries of local societies, and others interested in the objects your Committee are investigating, and who may be prepared to assist in the preparation of reports, will be kind enough to communicate with the Secretary.

Your Committee request reappointment without grant.

First Report of the Committee, consisting of Mr. W. H. PREECE (*Chairman*), Professor H. S. HELE SHAW (*Secretary*), Messrs. B. BAKER, W. ANDERSON, *and* G. KAPP, *and* Professors J. PERRY *and* R. H. SMITH, *appointed to report on the Development of Graphic Methods in Mechanical Science.*

THE work of the Committee for the past year has been limited to preparing (1) a list of authorities upon the subject of Graphic Methods. In this list are placed only those publications which are avowedly for the

purpose of dealing graphically with problems in mechanical science. A large number of standard works based to a great extent on graphic methods are thus necessarily excluded; (2) a short report on graphical methods in applied electrical science.

The presentation of the Report on the other portions of the subject is delayed until a future date.

List of Authorities on the Subject of Graphic Methods.[1]

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[1] The Committee will be glad to receive through the Secretary the names of other authorities on the subject and titles of their works or memoirs.

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Jenkin, Fleeming H. 'The Application of Graphic Methods to the determination of the efficiency of Machinery.' Trans. Royal Soc. Edin., vol. xxviii., 1877.

Klasen, L. 'Graphische Ermittelung der Spannungen in den Hochbau- u. Brückenbau-Konstruktionen.' Leipzig, 1878.

Küpper, C. 'Einleitung in die Mechanik durch rein geometrische Betrachtungen.' Trier, 1866.

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Maurer, M. 'Statique graphique appliquée aux constructions, toitures, planchers, poutres, ponts, etc.' Paris, 1886. 2 vols.

Müller-Breslau, H. F. B. 'Die neueren Methoden der Festigkeitslehre und der Statik der Baukonstruktionen.' Leipzig, 1886.

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Graphical Methods in applied Electrical Science.

In practical electrical science graphical methods have not as yet found much favour. This is probably owing to the fact that most of the problems relating to electric lighting and telegraphy present no difficulties of a mathematical character, and can be very readily solved by ordinary numerical methods. There are, however, two cases in which the use of a geometrical construction leads to a more direct solution. The most important of these is the application of the characteristic curve of a dynamo to questions connected with its working.

(1) In the form originally suggested by Dr. J. Hopkinson[1] a characteristic curve is one whose ordinates represent the electromotive force of a dynamo running at any given speed, and whose abscissæ give the corre-

[1] Hopkinson, *Proc. Inst. Mech. Eng.*, April 1879; *ibid.*, April, 1880.

sponding values of the current passing round the armature. M. Marcel Deprez[1] demonstrated their practical utility, and (a) showed that, amongst other things, they can be used to determine the current produced by a dynamo in an external circuit of known resistance and containing a constant opposing electromotive force (*e.g.*, a dynamo charging accumulator cells); (b) gave a construction which was practically the first step taken towards the present system of calculation of compound winding of the coils in a dynamo in order to secure a constant E.M.F. through a system of lamps arranged in parallel circuit, or a circuit of lamps arranged in series; and (c) explained a method of transforming the characteristic curve of one dynamo to that of another having wire of different thickness, but the winding occupying the same volume (*i.e.* the same skeleton dynamo wound with different wire). The constructions of M. Deprez are given in MM. Mascart and Joubert's 'Treatise on Electricity.'[2] Dr. Hopkinson[3] has applied a curve, easily derived from the characteristic, to find the maximum useful work which can be transmitted from a series-wound dynamo to a motor when the resistance of the whole circuit is known. The derived curve has ordinates $\frac{d(\mathrm{E\,C})}{d\mathrm{C}}$ and abscissæ C, corresponding to E and C respectively of the characteristic. The points on it are obtained by a geometrical construction which depends upon the fact that $\frac{d\mathrm{E}}{d\mathrm{C}}$ is the slope of the characteristic curve at any point.

The characteristic curve of a dynamo requires for its construction an *experimental* knowledge of the relation between the magnetic field of the armature (which determines the electromotive force) and the corresponding current, for every value of the latter. Hence it cannot be applied to those problems in which the best method of constructing the dynamo itself is concerned (with the exception of the particular case in which a dynamo is re-wound). Several attempts have been made to overcome this difficulty, but they give only an approximation to the characteristic, chiefly owing to the fact that the exact relation between the magnetism developed in the iron core of an electro-magnet and the current passing through its coil is unknown. Drs. J. and E. Hopkinson[4] have made experiments on the magnitude of the waste field of an Edison-Hopkinson dynamo, and, starting from the dimensions of the machine, have calculated a theoretical approximation to its characteristic. They assumed a relation for the magnetisation function and constructed a curve, which agrees fairly well with actual experiment. Ayrton and Perry,[5] on the other hand, have recently shown that by making two assumptions one can easily obtain a very good approximation to the actual curve. The first of these is that for low values of the current the permeability of the iron part of the magnetic circuit is very great compared with that of the air; hence, practically, the whole of the magnetic resistance is due to the air gap. This gives for the part of the characteristic near the origin a straight line, which can be drawn when the length of the air gap is known. One point on the upper (curved) part of the characteristic is next determined

[1] Marcel Deprez, *Comptes Rendus*, xcii. (1881), p. 1152; xciii. (1881), pp. 892 and 950.

[2] Mascart and Joubert, *Electricity*, vol. ii. (Atkinson's translation), pp. 724–735.

[3] Hopkinson, *Proc. Inst. C. E.*, April 5, 1883.

[4] J. & E. Hopkinson, *Phil. Trans.*, 1886, p. 331.

[5] Ayrton & Perry, *Phil. Mag.*, June 1888, p. 496; *Proc. Phys. Soc.*, ix., p. 220.

by the fact that when the machine yields its best permanent electric output the magnetic resistances of the iron and the air space are equal. To find this point it is only necessary to fix the value of the magnetic field at which it is desired to work the dynamo. The upper part of the curve is then drawn to coincide with that particular Fröhlich's curve of magnetisation (a hyperbola) which passes through the point found above and a point on the straight line, previously found, corresponding to a field of 10,000 units (C.G.S). The passage from the straight line to the Fröhlich curve is drawn by hand.

The authors state that such a curve suffices for solving all ordinary problems connected with the proposed dynamo, but it is scarcely accurate enough to apply to such questions as relate to the compounding of the coils of the machine and the regulation of its current. These, in general, must be left alone until the machine is constructed and an experimental characteristic determined.

(2) In connection with alternate current work, Blakesley [1] has published some very interesting graphical solutions of questions relating to self-induction, mutual induction, and capacity; but, as they refer only to the case in which the electromotive force is a simple sine function of the time, they have not been used in practical work. They depend upon the fact that the counter-electromotive forces acting in a circuit, set up by self-induction or mutual induction, and opposing an original harmonically varying electromotive force, themselves vary harmonically, and have the *same* period as the original electromotive force. Consequently the effective electromotive force in the circuit at any moment can be found by combining all the separate E.M.F.'s by the parallelogram law as applied to simple harmonic motions in general. Although the case considered is never realised in practice, some dynamos very approximately fulfil the conditions, and the author has ventured to extend the solutions to the case of the transmission of power by alternating currents and the determination of the conditions under which the maximum efficiency is obtainable.

Report of the Committee, consisting of Sir J. N. DOUGLASS, Professor W. C. UNWIN (*Secretary*), Professor OSBORNE REYNOLDS, *and* Messrs. W. TOPLEY, E. LEADER WILLIAMS, W. SHELFORD, G. F. DEACON, A. R. HUNT, *and* W. H. WHEELER, *appointed to investigate the Action of Waves and Currents on the Beds and Foreshores of Estuaries by means of Working Models.*

[PLATES I.–IX.]

THE Committee held their first meeting in the Central Institution of the City and Guilds of London Institute. It was then resolved that the Committee should avail themselves of the permission of the Council of the Owens College, and conduct their experiments in the Whitworth Engineering Laboratory.

At the suggestion of Professor Reynolds it was arranged that the first experiments should be directed to determine in what respects, and to what extent, the distribution of sand in the beds of model estuaries of

[1] Blakesley, *Electrician*, 1885, passim; reprinted in book-form in *Electrician* series Also *Phys. Soc. Journal*, ix. p. 85 (Jan. 1888).

similar lateral configuration is affected by the horizontal and vertical dimensions, and the relation which these bear to one another and to the tide period so as to place the laws of similarity on which the practical applications of the method depend, on as firm an experimental basis as possible.

It was suggested provisionally that two working tanks should be constructed, one as large as the circumstances of the laboratory would admit, and one of half the linear dimensions of the larger tank. Professor Reynolds was empowered to appoint an assistant to make the necessary observations.

At a second Committee meeting, held at Owens College, Manchester, the models constructed were examined, and it was arranged that Professor Reynolds should draw up a report on the results so far obtained.

On Model Estuaries. By Professor OSBORNE REYNOLDS, *F.R.S.*

Having carefully considered and sketched out designs for the tanks and appliances in accordance with the resolutions of the Committee on February 6, I obtained the assistance of Mr. H. Bamford, B.Sc., from Easter up to the date of the meeting at Newcastle. The working drawings for the appliances were commenced immediately after Easter, and the work put in hand, the experiments being commenced in each tank as soon as it was ready.

The General Design of the Appliances.—A great object in designing the tanks was to make the most of the facilities in the Whitworth Engineering Laboratory, Owens College, in respect of a continuously running shaft, a supply of town's water and wastes, also a water supply (13,000 gallons) from a storeage tank at 116 feet above the floor of the laboratory, and a discharge into a similar tank below the floor, with pumping power to raise the water back when required, also floor space.

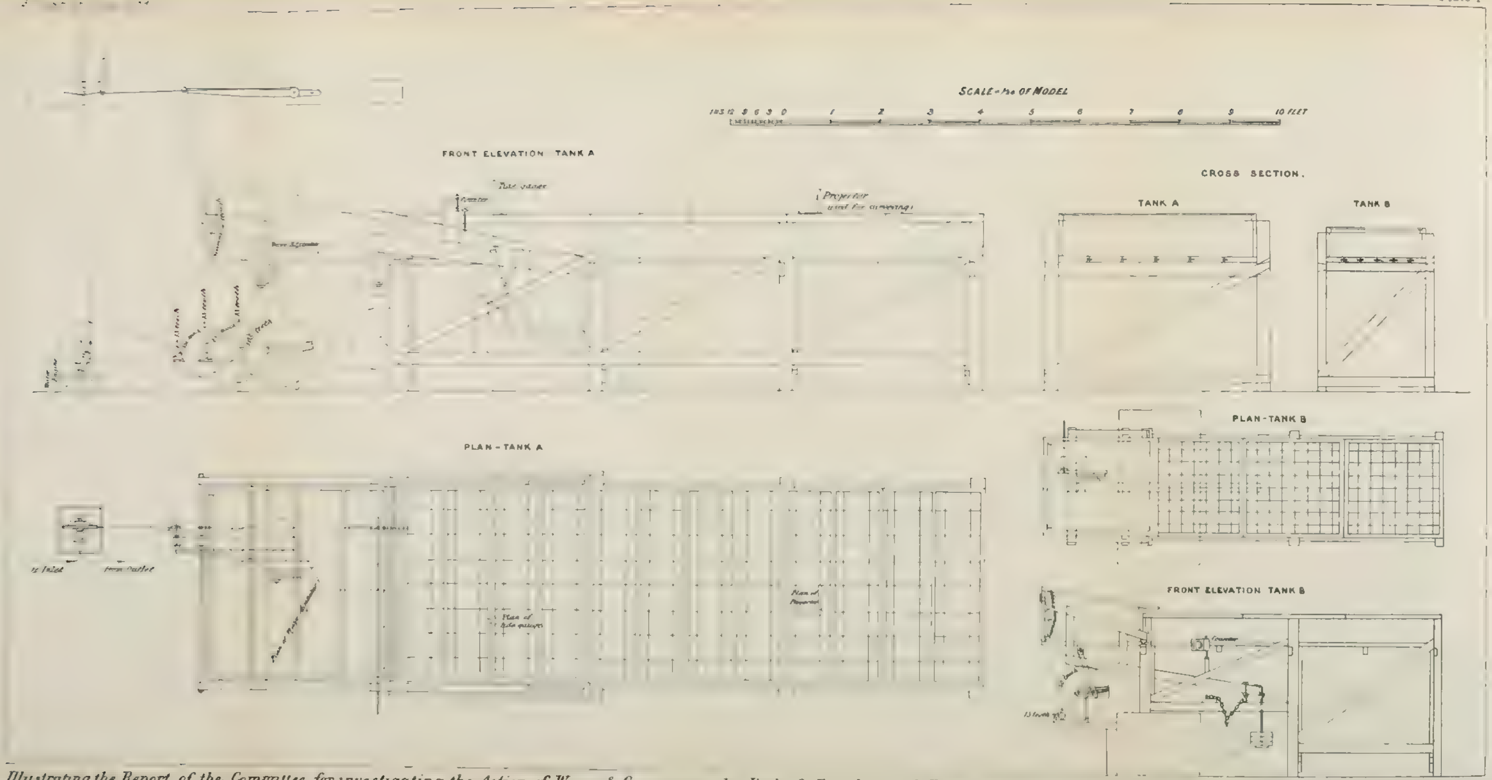
The available floor space, although very conveniently placed with respect to the water and power, was strictly limited by resisting structures to 10 feet wide and 22 feet long. This admitted of an extreme length for the larger tank of 16 feet, and an extreme width of 4′ 8″, leaving 2′ 6″ for the width of the smaller tank, the remainder of the space being the least possible that would admit of access to all parts of the tanks. The internal dimensions of the tanks as designed are :—

TANK A.

—	Length	Breadth	Height
Fixed rectangular tray having one end open	11′ 10½	3′ 9½″	—
From laboratory floor to floor of the tray	—	—	2′ 6″
Sides and end above the bottom . .	—	—	9″
Tide generator, one end open . .	3′ 10½″	3′ 9½″	—
Sides at open end	—	—	9″
At closed end	—	—	1′ 7″

TANK B.—Half the dimensions of A.

The proportions of the tide-generators and fixed pans were determined, so that in tank A the greatest rise of tide over the whole tank should be 2″; which was double the tide used in my previous experiments,



Illustrating the Report of the Committee for investigating the Action of Waves & Currents on the Beds & Foreshores of Estuaries by means of Working Models.

and that consistently with this the generators should be as short as possible. This tide in tank A required that the generator should displace 10 cubic feet, and as the greatest rise and fall that could be conveniently obtained for the end of the generator was 16″, giving a mean rise of 8″, the area required was 15 square feet.

A period of 30 seconds was adopted for tank A as the shortest period likely to be required, and the gearing arranged accordingly. With this period, and a 2″ tide, the horizontal scale would be 1 in 20,000 of that of a tank with a 30-foot tide, and a period of 12 hours 20 minutes. So that the 12-foot pan would represent 45 miles.

Provision was made for the production of waves with periods $\frac{1}{300}$th the tidal period.

Provision was also made for the introduction of land water into the tank at any point that might be required; also for scumming the water by an adjustable weir, which would serve to keep the level of low water constant, water being supplied into the generator when no land water was required.

The drawings (Plate I.) show the tanks and apparatus as they have been constructed. The pans and tide generators are of pine-boards fastened with screws. The former rest in a fixed cradle formed by six legs with cross-bearers, bottom ties, and braces. The floor boards of the pan are screwed to the cross-bearers, but are left free to expand, the joints being made with marine glue, after the manner of the decks of ships. The sides are screwed to the floor only; they receive lateral support against the pressure of the water from the prolongations of the legs upwards. The pans are lined with calico saturated with marine glue, and put down with hot irons, then covered with a coat of paraffin. The pans of the generators are constructed in the same way as the others, only instead of the cross-bearers being attached to legs they are suspended from two side levers which are supported on cast-iron knife-edges resting in cast-iron grooves on the top of the legs at the end of the pan. These knife-edges are at the exact level of the top of the floor of the pan, and in line with the joint in the floor between the pan and the generator, so that there is no opening and closing of this joint. This joint is, however, covered with indiarubber, which extends up the sides, and by stretching allows for the opening and closing of these joints.

In tank A these side levers extend 4 feet along the sides of the pan, beyond the joint, and to their ends is attached a large box for holding balance weights. These weights are considerably below the knife-edges, and consequently their moment diminishes as the box descends, *i.e.* as the tide rises, but this diminution by no means compensates the diminution of the water in the generator.

If, therefore, sufficient weight were put into the box to balance the generator when the tide is low, it would much overbalance it when the tide is high. To meet this the weights in the box are used mainly to balance the dead weight of the generator, which requires about 300 lbs. and a varying balance is arranged for the water.

This varying balance consists, in tank A, of a cast-iron cylinder of 500 lbs. weight suspended by links from the side levers across under the tank. The cylinder is also suspended by two links from the frame, and this second suspension is so arranged that when the generator is down the links from the levers are vertical, and when the generator is up they are horizontal. In this way a varying balance is obtained, which as far

as possible effects a complete balance in all particulars. In tank B, arrangements which have the same effect have been carried out in a somewhat different manner, which will be clear from the drawings.

The glass covering for tank A consists of eight glazed frames, each having two panes of sheet glass $3' 10'' \times 10''$, with $\frac{1}{4}''$ bearing on the frame all round; the external dimensions of the frames are $4' \times 2'$, so that they are easily handled. The glass is let in flush with the top of the wood, and each pane is fixed by four small brass clips screwed to the frame. In this way, except for the clips, the top of the glass cover over the pan presents a level surface. The frames over the tide generator are connected with those over the pan by a hinge joint made of two strips of pine hinged to each other and to the frames.

A somewhat similar arrangement exists in tank B, except that there are only four frames each with a single pane $2' \times 2'$. In both tanks the glass frames are fastened by screws to the sides, which screws have to be taken out before the frames can be removed.

The gearing, which is arranged to be driven either from a small water-engine or the running shafting, is shown in the drawings.

The crank is adjustable so as to give any required tide up to the maximum. In tank A, the pulley driven by the belt from the motor or shaft makes 700 revolutions for one of the crank, and has a fly-wheel which considerably helps the motor over any little irregularities in the balance. The gearing in tank B is driven either direct from the motor or from a pulley on the second shaft in the gearing of A, in which way a fixed relation in speed is obtained when the tanks are working together. The motor was obtained from Alderman Bailey, Albion Works, Salford; it is a double-acting oscillating water-engine with a $\frac{3}{4}''$ piston and $4''$ stroke. The available pressure of water is 50 lbs. steady pressure; the consumption is about 1 gallon per 100 revolutions. At the highest speed, 2 tides a minute, the motor only makes about 200 revolutions per minute, so that the 13,000 gallons will keep it going over three days, and has done so from Saturday till Tuesday, Monday being Bank Holiday. It has run day and night and Sunday, since starting in June, without once stopping, making over 12,000,000 revolutions, and is none the worse. If it used the full pressure it would, when run at 100 revolutions, do about ·044 horse-power. Owing to the careful balance of the tanks and the use of spur instead of worm gearing, the work required is not more than ·008 horse-power, so that five-sixths of the pressure is spent in overcoming the fluid resistance, which, increasing as the square of the speed, affords a very important means of regulating the speed, which, indeed, is thus rendered very regular.

Surveying Appliances.—Since the configuration of the sand produced under different circumstances can only be compared by means of records such as charts or sections, the practicability of the investigation depended on the finding of some means by which the sections or contour-lines on the sand could be rapidly and accurately surveyed.

The floor of the estuary was made flat and carefully levelled, so that the depth of sand at any point could be at once ascertained by sinking a fine scale through it to the bottom; and for this purpose scales were constructed of strips of sheet brass $\cdot 01'$ broad and $\cdot 01''$ thick. On these the alternate $\cdot 01'$ were painted white, and the intermediate spaces in the first $0'\cdot 1$ were painted red, in the second $0'\cdot 1$ black, and so on, the scales being then varnished with paraffin.

These scales would stand in the sand edgeways to the current, and so be made into permanent sand-gauges, which could be read periodically without removing the glass or stopping the tide. For tank B the scales were half the size of those for tank A.

The resistance which a few such thin obstructions offered to the water would be very small, but if the gauges were numerous the resistance would be a serious matter, so that a more general method of taking a final survey was necessary.

The ease and simplicity with which the contour-line could be found when the tides were not running, by adjusting the level of the still water and observing its boundary on the sand, reduced the question of making a contour survey to the providing of the means—

1. Of adjusting the level of still water to any required height.
2. Of rapidly and accurately determining the horizontal position of points on the edge of the water.

The tide-gauge, shown in the drawing on the top of the tank, which would stand on the glass which gave a level surface, answered well to determine the level of the water.

For the purpose of surveying the contours a system of horizontal survey-lines were set out in the covering frames, consisting of black thread stretched immediately beneath the glass in the frames. The lines are 6″ apart; those parallel with sides are called lines, and those at right angles sections. The first section is 3″ from the end of the tank [1] and the lines are so placed that one of them bisects the tank.

These survey-lines divide the entire surface of the fixed tray into equal squares. They are, however, 11″ from the bottom and about 8 from the sand; besides, they are six inches apart, so that to make accurate use of them for surveying the sand it was necessary to use some means of projecting a point vertically up to the level of the glass and scale its distance from a line and a section. This is accomplished by a little instrument, which may be called a projector, shown on the top of tank A.

It has a foot which consists of two scales placed at right-angles, so that the zero-lines on both, if produced, would meet in a point about half an inch from the edge of the scale. About this point there is a hole through the foot with cross-wires so placed that they intersect in the point of intersection of the zero lines. Vertically above this is a horizontal plate with a pin-hole, so that when placed on the horizontal glass any point below seen through the pin-hole on the cross-wires is vertically below the intersection of the zero-line of the scales; and hence if these scales are parallel to the lines and sections the distances of the point from these are read at once on the scales. This method of surveying lends itself readily to plotting on section paper. This may be done directly, the glass cover of the tank serving for a table; each point may be plotted as it is observed; and in this way Mr. Bamford is now able to survey and plot a complete contour-line in from fifteen to thirty minutes, and requires only about five hours to make a complete survey plotting the charts.

One very great desideratum has been a graphic recording tide-gauge. So much depends on the manner of rise and fall of the tide that it does not seem sufficient to know that it is produced by a simple harmonic motion; the curve should be recorded for each experiment at different

[1] This somewhat awkward arrangement was necessary on account of the wood in the frames.

parts of the tank. The want of means and time has prevented any attempt to supply such a gauge.

Curves have been obtained for most of the experiments by means of the simple tide-gauge. The crank-wheel being divided into sixteen equal arcs, one observer observes the wheel and another the gauge. When a particular number comes to the index the observer at the wheel calls, and the other observer reads the gauge, and then shifts the sliding pointer to the point at which the tide-index was, so that on the next revolution, when the call comes again, he can observe if the pointer coincides exactly with the index or requires adjustment. Having brought about coincidence, he then proceeds to the next number. In this way it takes about half an hour to read the curve. Time, however, is not the only objection, a greater one being that any irregularities in the motion of the wheel do not appear in the curve. The motion of the wheel has been as far as possible checked by the clock, but still there is room for important errors, which a chronograph would obviate.

The Selection of Sand.—Sir James Douglass having informed me that clean shell sand could be obtained, and having sent me samples which, from the tests to which I subjected them, seemed to be quite as readily moved by the water as the finest Calais sand, I asked him to procure a quantity—fifteen bushels of Huna Bay shell sand—and in the meantime I procured a similar quantity of Calais sand, so that I might be prepared with whichever showed itself best in actual experiments.

Selection of the Experiments.—It having been decided that in the first instance the purpose of the experiments should be the comparison of the distributions of sand produced under particular lateral configurations, and with different relations between the vertical and horizontal scales in the same model, and with similar relations in these scales in the two models, the only matters left for selection in starting these experiments were the scales and particular configurations.

There was apparently no reason for attempting the very difficult operation of modelling any actual estuary, and, setting this aside, the question of choice mainly turned on whether it was best to begin with complex or simple circumstances. There was considerable temptation to commence with complex, *i.e.*, boldly irregular boundaries, so that the influence of the boundaries might predominate over such other influences as exist; in which case the influence of the boundaries would be tested by the similarity of the distributions produced with different ratios of horizontal and vertical scales. On the other hand, however, it appeared that as the main object of these researches is to differentiate and examine the various circumstances which influence the distribution of the sand, it was desirable, in starting, to simplify as much as possible all the circumstances directly under control, and so afford an opportunity for other more occult causes to reveal themselves through their effects, and to determine the laws of similarity of these effects.

The simplest of all circumstances would be that of no lateral boundaries whatever—a straight foreshore of unlimited length with a shelving sandy beach, up and down which the tide runs until it has brought the beach to a state of equilibrium.

This being an impossibility, the nearest approach to it is that of a beach or estuary with vertical lateral boundaries parallel to the direction of flow of the tide. And the broader such estuary is in proportion to its length the less would be the effect of the lateral boundaries. The effect

of the tide running straight up and down such an estuary might tend to shift the sand up or down according to the slope at each point, and the period and height of the tide, or until some definite relation between these three quantities was attained. If such a relation exists, its elucidation would seem to be fundamental to a full understanding of the régime of estuaries.

Further, there was the very important question how far such a tidal action would leave the bed beach-like, with uniform slope and straight contours, or groove it with low-water channels as in the mouths of estuaries, *i.e.* whether a parallel estuary without land water, having a uniform slope and straight contours, would be stable under the action of a tide of which the general motion was straight up and down?

Considering that the new rectangular tanks with their clean paraffined sides were admirably adapted for such experiments, and that any internal modelling would have required further time, which was already very short, if a report was to be presented at the Newcastle meeting, it was decided to commence with a series of experiments on the general slope and configuration of the sand with parallel vertical sides, after making some preliminary experiments while the tank A was having a preliminary run to test the working of the motor.

Following is an abstract account of these experiments and the results obtained. It has not been thought desirable to introduce into this report a complete copy of the note-book. The initial conditions of each experiment are given, together with the date, the number of tides run, and the mean period of the tide; also notes made during the running on circumstances which are likely to have affected the general results. The final results are contained in the charts (or plans as they are headed), the longitudinal and cross sections which have been taken from the charts and the diagram of mean slope obtained from the areas of contours. These are all appended to the report.

Preliminary Experiments with Balls.—Little balls of paraffin the size of peas were prepared, colouring matter having been first mixed with the paraffin to distinguish the balls, and to so load some that they would just sink while others floated. Then, before the motor was started, the water being quite still, the balls were placed in rows across the tank at definite distances down the tank, and from the centre line—one set of balls on the bottom and another set floating above. The motor was then started, and the change in position of the balls noted.

It was supposed that the floating balls would move with the water and show by any change of their mean position if there was any circulation in the water. This was what they did when the surface of the water was perfectly clean, but the slightest scum very greatly diminished the range of the motion of the floating balls. This matter of scum, if it can be so called, when it is entirely unperceivable by the eye, is very important in these model experiments; for, however slight it is, it tends to prevent the horizontal motion of the immediate surface, and indirectly to modify the internal motion of the water; the only test of perfect freedom from surface impurity is that small drops caused by a splash falling on the surface float along. When the surface was in such a state the floating paraffin balls oscillated up and down with the water, and kept the position for many oscillations both up and down and across the channel.

The sinking balls are subject to the constant resistance of the bottom,

so that their motion is not equal or proportional to the motion of the water—for a sufficiently slow motion of the water the ball would not move; so that if the ebb were just not sufficient to move the ball, and the flood were stronger, the ball would be moved up each tide, or *vice versâ*, and the same resultant motion would follow, even though the ball might be moved somewhat by both ebb and flood; the strongest would carry the ball farthest. In this way they furnished a very delicate test as to the symmetry of the tides and the sufficiency of the balancing.

Experiments on the Movement and Equilibrium of Sand in a Tide Way.

Series 1.—Tide running in a uniform rectangular pan with vertical sides and end, and a level bottom for the sand to rest on.

Experiment 1 (tank A), commenced June 22.—Three cubic inches of Calais sand were placed in a heap on section 17 and line $1r$, and 3 cubic inches of Huna Bay shell sand similarly on section 17 and line 1_r, the tank being otherwise clean and empty. Then, with low water 0·083 of a foot and high water ·23′ from the bottom, the tide was set running with a period of 55 sec. After 3,000 tides, the white sand spread upwards from section 16·5 to 12·7 in 7 ripples, having just painted the bottom 1 grain thick down to section 22.

The Huna Bay shell sand spread upwards from section 18 to 14·25 in 4 ripples, also having painted the floor down.

Experiment 2 (tank A), commenced June 24.—Calais sand was introduced as a uniform bank across the channel.

Experiment 3 (tank A).—The Calais sand was arranged exactly as for Experiment 2.

Experiment 4 (tank A).—A repetition of Experiment 3, observations being directed more closely to the motion of the sand after starting.

Experiment 5 (tank A), July 5 (Plans III. to VI.).—Calais sand passed through a sieve into the tank, in which there was sufficient water to cover the sand until there was enough sand to fill the tank from the upper end to section 18, to a depth of 0·25 foot, terminating in a natural slope from section 18 to the floor. Then the sand, which was in excess at the upper end, was carefully levelled by means of a wooden float guided on the sides of the tank, and having its straight edge completely across the tank 0·25 foot from the bottom. The scummer was then adjusted to keep the low water at 0·181 from the floor, and the crank adjusted to give a rise of 0·166 over the whole tank. The actual rise at starting, owing to the sand above low water, was 0·2′ over the whole surface.

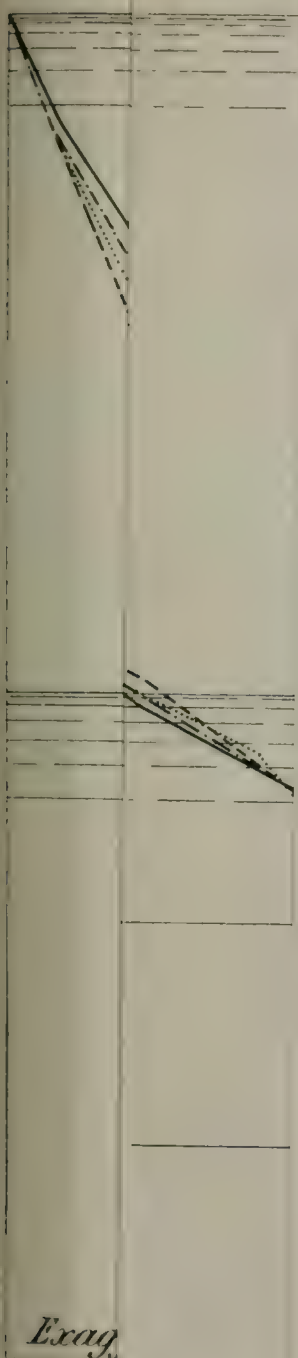
The tank was then started, and ran 12,607 tides at a period of 53 secs., when the speed was increased to 50 secs. and continued for 3,589 tides; then, as the condition seemed very steady, the survey for Plan I. was made.

At the starting of the tank careful note was taken of the progressive appearances, and during the interval of running, which occupied from July 5 to July 15, sand gauges were introduced and read daily, as well as other notes of progress made. The periods of rise and fall of the tide were checked, and a curve taken which showed the rise and fall at the generator to be symmetrical and nearly harmonic.

The sand was found to descend down the tank towards the generator

59th Rep

FIG. 2.



Foreshore.

FIG 1 FIG 2

Exaggeration of actual Slopes = 31

Plan 1 } Experiment V. } Tank A
Plan 4 }
Plan 1 Experiment VII }
Plan 1 Experiment III Tank B

Illustrating the Report of the Committee for investigating the Action of Waves & Currents on the Beds & Foreshores of Estuaries by means of Working Models.

The figures on the Contour lines show their actual distances
in the model above or below low-water-level in decimals of a foot.

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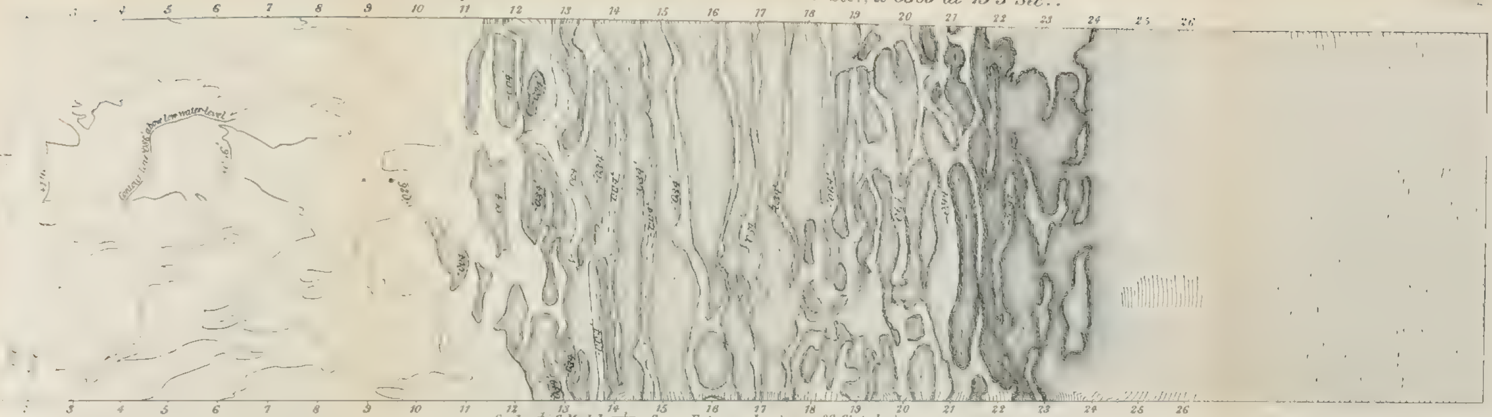
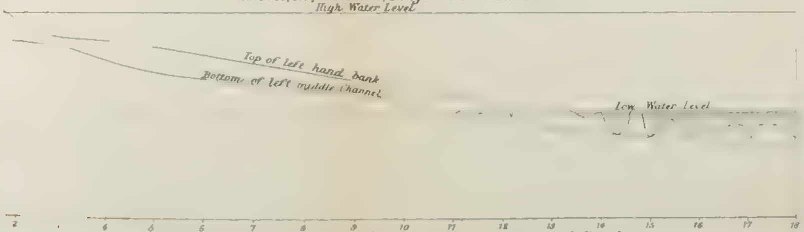
Tank A. Experiment V, Plan I, after 12697 tides at 53·4 Sec.s, & 3589 at 49·3 Sec.s.



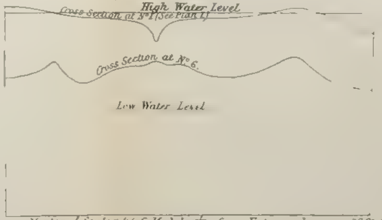
Scale - 1/12 (of Model - 1/1138 of an Estuary having a 30 ft. tide.)

Tank A, Experiment V, Longitudinal Section I.



Horizontal Scale - 1/12 (of Model - 1/1138 of an Estuary having a 30 ft. tide)

Tank A, Experiment V, Cross Section I.



Vertical Scale - 1/2 (of Model - 1/10 of an Estuary having a 30 ft. tide)

Illustrating the Report of the Committee for investigating the Action of Waves & Currents on the Beds & Foreshores of Estuaries by means of Working Models.

The figures on the Contour lines show their actual distances in the

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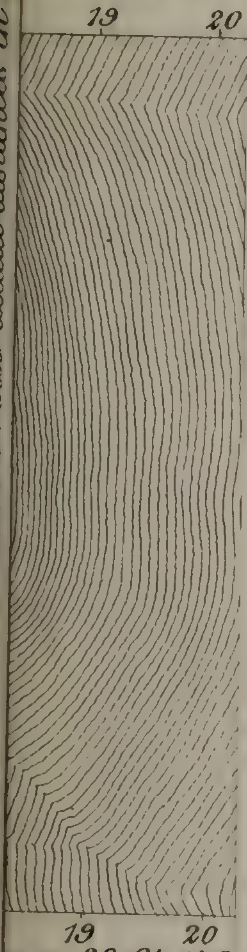

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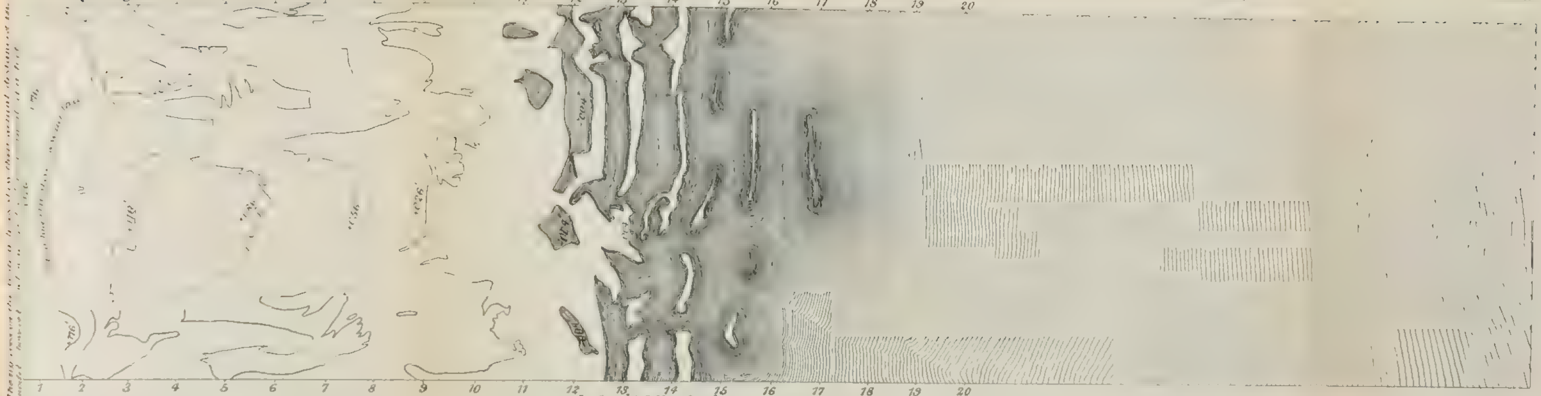
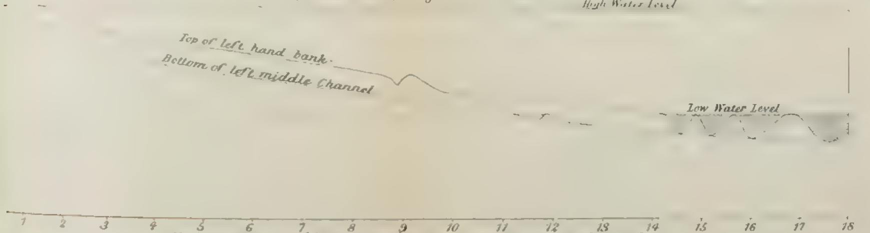
Tank A, Experiment V, Plan II, after 12697 tides at 53·4 Secs 3589 at 49·3 Secs & 7815 at 65·1 Secs.



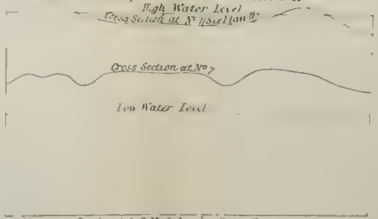
Scale - 1/12 (of Model - 8903 of an Estuary having a 30 ft tide)

Tank A, Experiment V, Longitudinal Section II



Horizontal Scale 1/12 of Model 8903 of an Estuary having a 30 ft tide)

Tank A, Experiment V, Cross Section II



Vertical Scale - 1/4 (of Model - 1/10 of an Estuary having a 30 ft tide)

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The figures on the Contour lines show their actual distances in the model above or below low-water-level in decimals of a foot.

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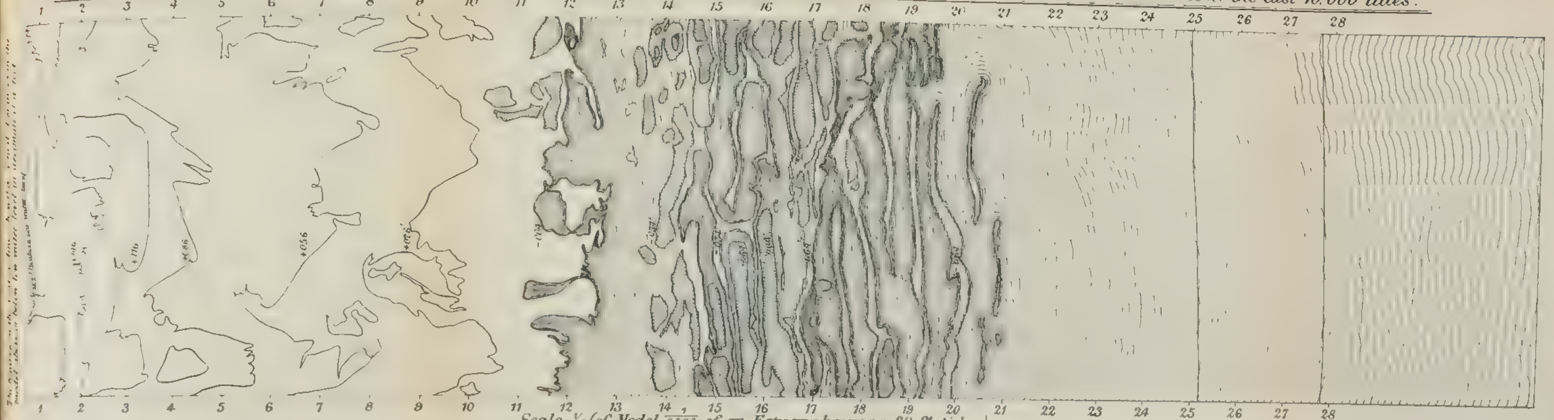
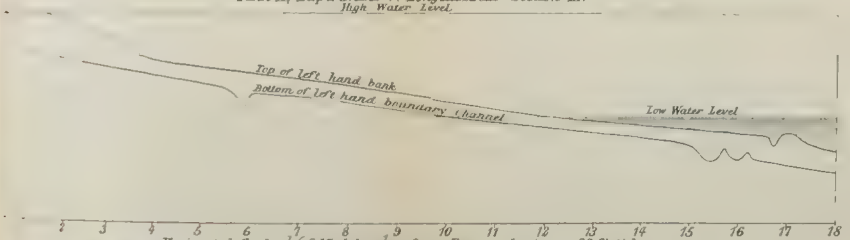
Tank A. Experiment V. Plan III, after 12697 tides at 53·4 Secs 3589 at 49·3 Secs 7815 at 65·1 Secs & 17750 at 60·6 Secs with intermittent waves for the last 10,000 tides.



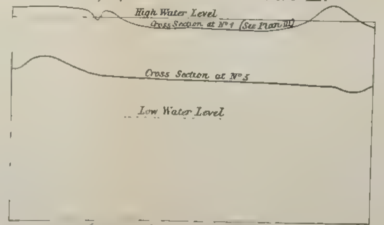
Scale $\frac{1}{12}$ (of Model $\frac{1}{9566}$ of an Estuary having a 30 ft. tide.)

Tank A, Experiment V. Longitudinal Section III.



Horizontal Scale $\frac{1}{12}$ (of Model $\frac{1}{9566}$ of an Estuary having a 30 ft. tide.

Tank A, Experiment V. Cross Section III.



Vertical Scale $\frac{1}{2}$ (of Model $\frac{1}{110}$ of an Estuary having a 30 ft. tide)

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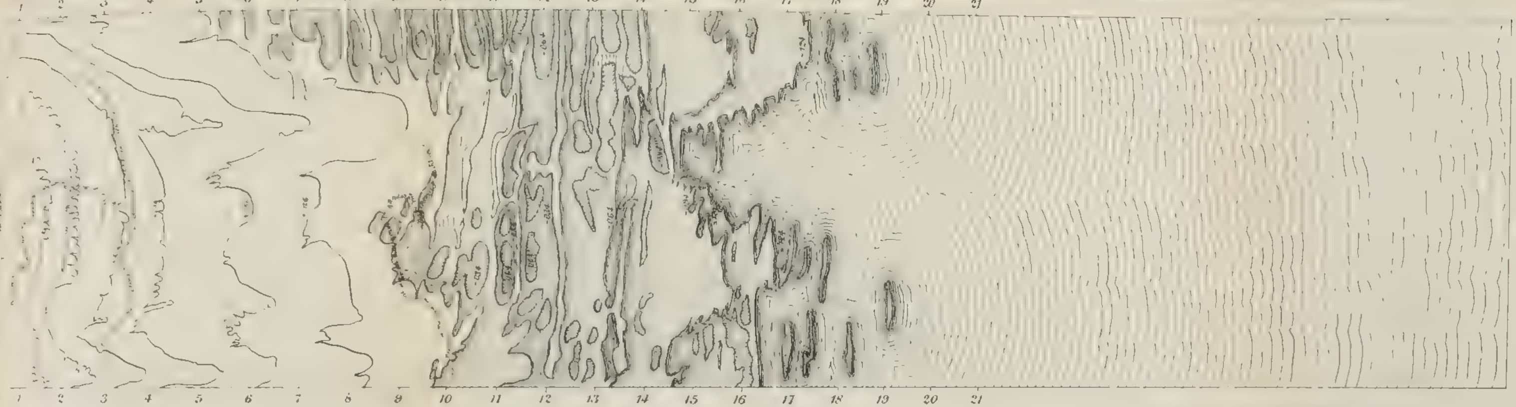
The figures on the contour lines show their actual distances
in the model above or below low-water level in decimals of
a foot

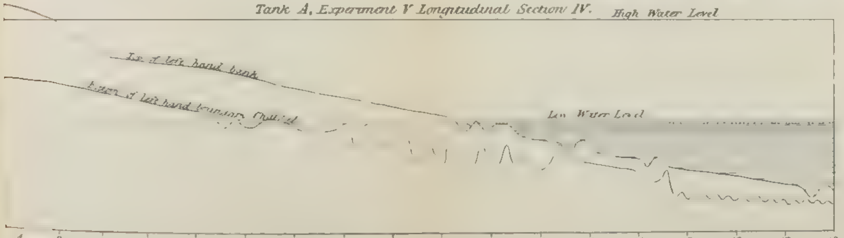
Ibres

Tank A Experiment V Plan IV, after 12697 tides at 53·4 Sec^s, 3589 at 49·3 Sec^s, 7815 at 65·1 Sec^s, 17750 at 60·6 Sec^s, & 12705 at 43·2 Sec^s, with intermittent waves for the last 22705 tides



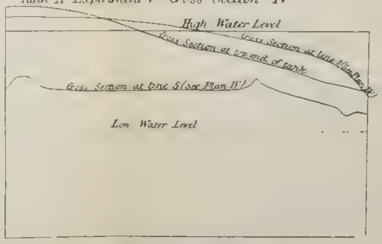
Scale = ½ (of Model $\frac{1}{13420}$ of an actual Estuary having a 30 f.^t tide.)

Tank A, Experiment V Longitudinal Section IV.



Horizontal Scale - ½ of Model.

Tank A Experiment V Cross Section IV



Vertical Scale - Half that of Model

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in a steadily diminishing manner, while at the same time it rose towards the head of the tank at a steadily diminishing rate, until both these changes ceased to be observable. The configuration of the surface also changed at a steadily diminishing rate. The chief features in this configuration were the banks, which gradually formed at the head of the tank in a very symmetrical form, and then extended down the tank past low-water level, losing their symmetry as the low-water channels between them began to take effect. These banks and channels appear clearly in the plan. The minor features were numerous minor channels caused by the water running off the banks. These covered the surface with very beautiful detail, which, however, it is quite impossible to record. Also ripple bars across the channel below low water.

After the first survey was taken the tank was started again July 17 at a somewhat slower period, viz., 66·7 seconds, and ran for 7,815 tides, when the second survey was made. The daily observation taken as before showed considerable changes of detail—so much so that it was a matter of surprise to find that Plan II. corresponded almost exactly with Plan I., the only difference being slight divergences and deepenings of the depressions and raising of the banks.

The tank was again started on July 25 at a period of 60·6, to keep the sand in motion until the agitator for producing waves could be put in action. This was accomplished after 7,780 more tides, from which no considerable change was observed. The agitator made 200 beats in the tide generator for every tide. At first the agitating bar was straight, 3′ 6″ long, with a section 6″ broad and $1\frac{1}{2}''$ deep. This caused parallel waves ·06′ high, ·8 long. The effect of the waves was at once apparent in the destruction of all the beautiful tracery on the banks, which soon presented a smooth washed-out appearance. After 4,000 tides a -shaped agitator, as shown in the drawing, was substituted for the first. This sent oblique waves of much the same size as before. The waves were kept going during the day and stopped at night; and after 6,000 further tides the tank was stopped to survey for Plan III. This shows that at low water the waves had to some extent levelled the sand; they had also washed off the ridges of the banks and filled the narrower channels; yet on the whole the depressions are deeper, and at the head of the estuary there is a marked change in the arrangement on the left side.

The model was (August 8) set to run at 33″ with the wave agitator going during the day. On the 19th it was found that so much additional sand had come down into the generator as to disturb the balance so as to require 100 lbs. additional weight to equalise the period, this was added, and again on Monday the 12th it was found that more sand had come down, requiring 50 lbs. more weight to re-establish the balance. On the 13th the sand was removed from the generator and the balance restored by removing the 150 lbs. It had also been found that from some cause the speed fell off considerably; at one time the speed was 70″. The cause of this was not at first perceived, but somehow the speed was restored, though it was subsequently found that the belt on the motor was slipping; this having been put right, the running at 33″ was continued till 12,705 tides had been run since this speed was commenced. Survey IV. was then taken. It was found that the mean period over the interval had been 43·2″ instead of 33″. It being uncertain how far the irregular speed and disturbed balance had affected the results, the model was started again August 16 to run at 33″ with a mean speed of 33″, and

after it had run 17,289 additional tides a partial survey was again taken and plotted in dotted lines on the plan showing Survey IV.

The dotted contours show a slight change, chiefly in the retreat of the low-water contour up the estuary, and a change in the distribution of the sand at the head of the estuary. These changes, however, are very slight compared with the great difference presented between Plan IV. and all the previous plans. In Plan IV. the contour ·004 lies between sections 6 and 11, while in Plan III. it lies between 12 and 13, which shows an increase from 1 to 1·47 in the general slope. The low-tide channel on the left has also increased in magnitude and length, extending nearly across the head of the estuary.

Experiment 6 (tank A), August 28.—In this experiment the initial conditions aimed at were precisely the same as in Experiment 5.

The sand which had been removed was returned, and all the sand well washed in the tank and then placed as before, the float having been examined and straightened on a surface plate.

After the sand was laid the water in the tank was brought as near as possible to the level of the sand, and was allowed to stand for twelve hours, when it was found that the sand looked drier on the right side than on the left. The generator was then raised by turning the pinion which, in the position the crank was, would raise the generator about ·008 of an inch for one revolution; this, considering the surface of water exposed, would raise the water ·005 inch, in which way it was found that the sand was something like ·01 of an inch higher on the right all along the tank.

The model was then started at the same speed as in Experiment 5, and the development carefully watched. In all respects it appeared to be the same as in the previous experiment, and the daily observations showed the same rate of progress; not only did the sand gauges and the descent of the sand agree, but the surface of the sand presented the same general appearance. The experiment was stopped after 8,686 tides, before it had reached the stage of the first survey, Experiment 5, so no survey was taken.

Experiment 1 (Tank B). August 5.—In starting this experiment it was intended that the circumstances should be in every respect homologous to those of Experiment 5 (tank A).

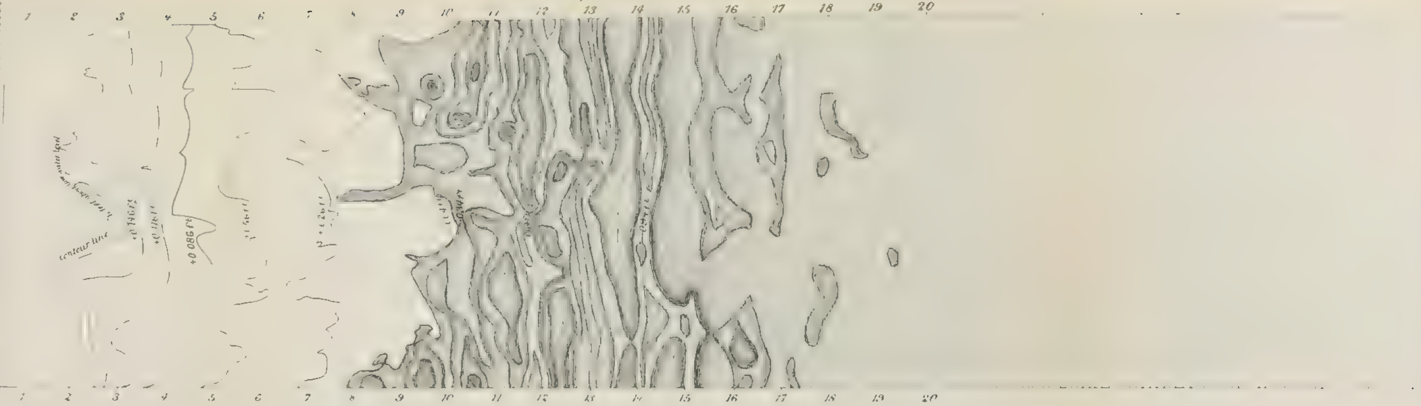
The sand was introduced in the same way, and brought to the same figure. The tank was started with a period of 36·5 seconds, that of A having been 53 seconds, which numbers are as the square roots of the dimensions of the tanks. The progressive appearances accorded identically with those noted in tank A, except in one apparently minor particular. And for the first 1,200 tides the downward progress of the sand was nearly the same (a trifle less).

About this stage an appearance presented itself which had not been noticed in the previous experiment. The arrangement of the sand appeared to show a greater rate of downward progression at the middle of the tank towards the generator than at the sides, and this was followed by a somewhat more rapid descent of the lower edge of the sand, which after 5,000 tides began to accumulate in the generator, from which about seven pounds was removed.

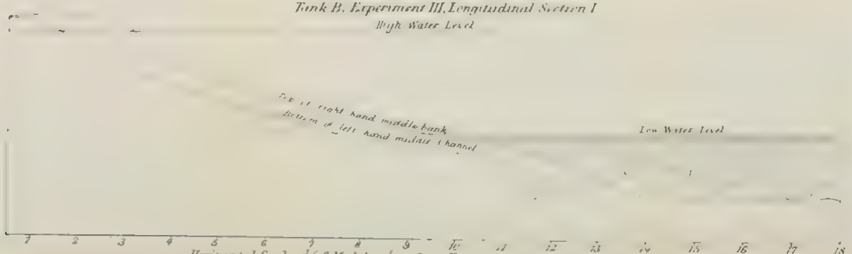
From this stage the lower end of the tank B differed considerably from that of tank A in the same stage. At the upper end the appearances were almost identical, and the reading of the sand gauges agreed well.

Tank B, Experiment III, Plan I, after 16,570 tides at 33.53 Sec.s

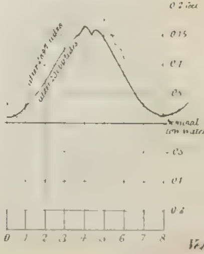
The figures on the Contour lines show twice their actual distances in the Tank above or below low water level in decimals of a foot.



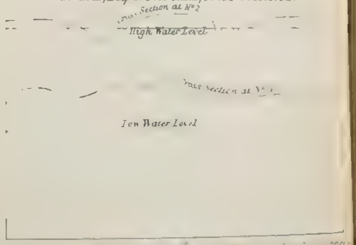
Tank B, Experiment III, Longitudinal Section I



Tide Curves



Tank B, Experiment III, Cross Section I.



Horizontal Scale-⅛ of Model-33640 of an Estuary having a 30 ft. tide.

Vertical Scale - Full size of the Model - 180 of an Estuary having a 30 ft.

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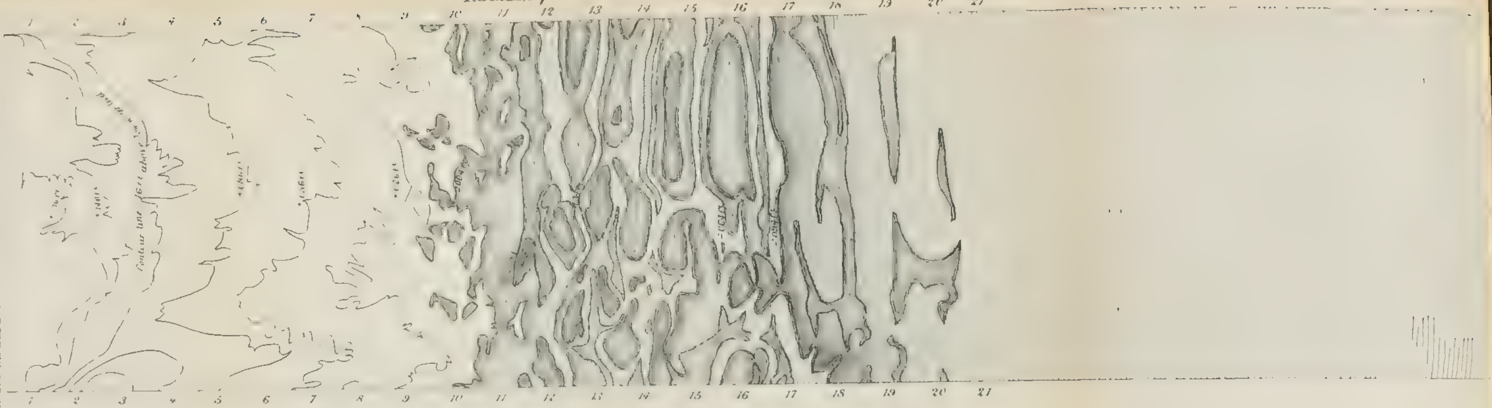
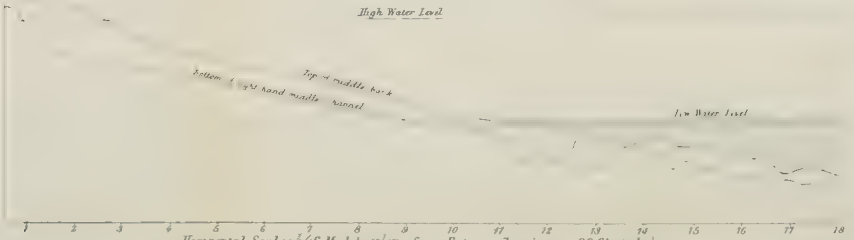
Tank A, Eperiment VII, Plan I, after 16733 tides at 33·4 Sec.s

The figures on the Contour lines show their actual distances in the model above or below low-water-level in decimals of a foot.

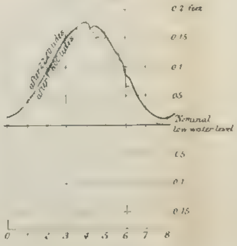


Tank A, Experiment VII, Longitudinal Section I,

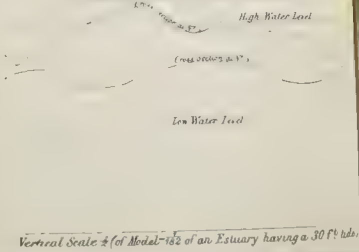


Horizontal Scale 1/2 (of Model = 1/13824 of an Estuary having a 30 ft tide)

Tide Curves



Tank A, Experiment VII Cross Section I



Vertical Scale 1/2 (of Model = 1/182 of an Estuary having a 30 ft tide)

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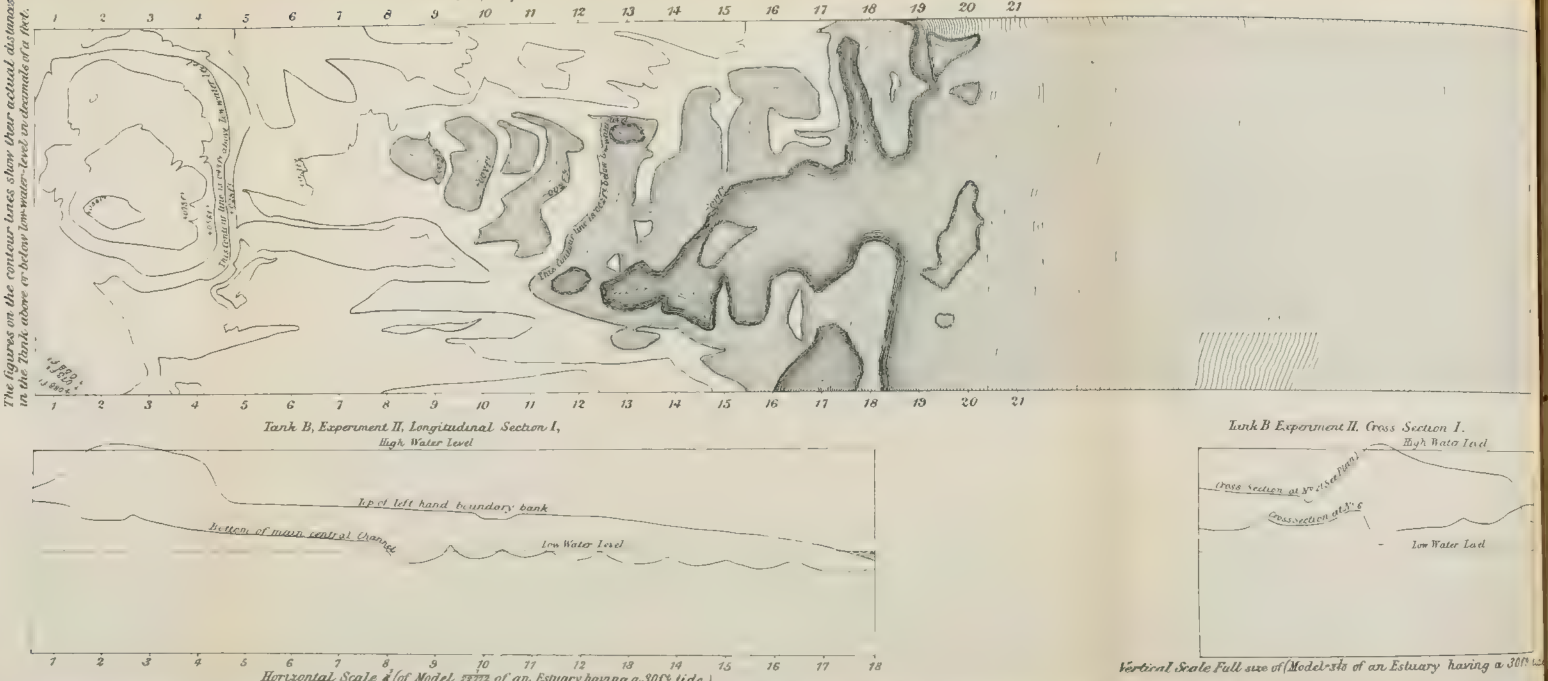
Tank B, Experiment II. Plan I, after 12058 tides 36·8 Sec^s & 4286 at 36 Sec^s



Illustrating the Report of the Committee for investigating the Action of Waves & Currents on the Beds & Foreshores of Estuaries by means of Working Models.

As the experiment progressed the sand, instead of having a nearly uniform downward slope from the head to the generator, had a uniform slope down the middle of the tank, with two large banks extending from section 8 to section 17 on each side, that on the right being longer. The experiment was continued for 11,013 tides, when it was found that the water was much too low, owing to misadjustment of the scummer; then as there was no possibility of saying how long this had been going on, the experiment was stopped.

Experiment 2 (Tank B, Plate VII.), August 28. Plan 1.—In this the conditions of experiment 1 were repeated, the edge of the float having been replaned. The results from starting were almost identical with those observed in Experiment 1. The sand again came down fastest in the middle, and faster than in tank A. Seven pounds were removed from the generator, and subsequently the condition of the model as regards the lateral banks was nearly the same, except that the longer bank was on the left. The experiment was continued with speeds exactly corresponding to those of Experiment 5, tank A, until 16,344 tides had been run; then Plan I. was taken. The tank was then set running again at 35·5 seconds and continued for 6,757 tides, when considerable changes had taken place towards the lower end of the tank. A partial survey was then made and recorded, and the experiment stopped.

Experiments 3 (Tank A, Plate VIII., and Tank B, Plate IX.), Sept. 2.—The sand in both tanks was arranged as before, a new float straightened to a surface plate being used for B, and the level of the sand in both tanks tested by water, as in experiment 6 A, which tests showed that the sand in A was perhaps ·01″ highest on the left, while in B it was to something like the same extent highest on the right.

The tanks were coupled, A being driven from the motor and B from A. Both were set to low tide at starting, and the start made at full speed, 33 seconds tank A. The progressive appearances simultaneously observed were identical, with the same exception as before noted. Immediately after starting the periods of rise and fall of the generator of A were observed, and the fall being slightly the larger 25 lbs. was removed from the balance weight, which restored the equality. After 77 tides it was observed that the sand in A was coming down much faster than in B, and had already begun to come into the generator; the periods of rise and fall were noted, and it was found that the rise was 17 seconds and the fall 15 seconds. The weight was replaced, the tanks stopped, and 56 lbs. of sand removed from the generator and lower end of the trough of A which left the end of the sand the same in both tanks. The tanks were then started, and the rise and fall in A were equal.

It may be well to remark that though the tank B is driven from A, the periods do not synchronise, so that the unequal motion caused by imperfect balance of A eventually affects all stages of the tide in B equally, while the resistance of B is so small compared with that of A, that any want of balance hardly affects the motor when driving both tanks. In starting there would be the same disturbance of balance in both tanks owing to the slow descent of the water from the flat sand, but it would be only that of A that would effect the balance.

After running 1,653 tides, tank A, it was seen that the sand had come into the generators of both tanks, so a stop was made, and all sand below section 20 again removed from both tanks—120 lbs. from A and 12 lbs. from B, making altogether 176 lbs. from A against 12 lbs. from B.

Considering that 1 lb. in B is equivalent to 8 lbs. in A, and that altogether in A there would be 1,100 lbs., B was left with about 7 per cent. more sand in proportion than A.

The experiment was then continued, the sand coming down in both tanks, but not so as to get into the generators. The motion of the sand in the two tanks followed almost exactly the same course, B gradually taking the lead. In this case there was not the least sign of the middle channel in B, the sand keeping level across and following the same course as had previously been observed in Experiments 5 and 6 A.

When B had run 16,570 tides it was stopped for surveying, while A was allowed to run on to make up the number of tides.

Surveys were then made.

Discussion of the Results Obtained.

Since the experiments have been arranged in accordance with the law of kinetic similarity, followed in my previous experiments, it may be well to restate this law before proceeding to discuss the results.

If h be the depth of water in a uniform trough, it is well known that the velocity of a wave, of which the length L compared with h is great, and of which the height is proportional to h, varies as the square root of h.

For geometrical similarity at any instant the lengths of the troughs must be proportional to L.

The period of rise and fall, p, will thus be inversely proportional to

$$\frac{\sqrt{h}}{L}$$

Hence for the law of kinetic similarity,

$$\frac{p\sqrt{h}}{L} \quad . \quad . \quad . \quad . \quad . \quad (1)$$

has a constant value for all scales.

This law takes no account of the resistance of the bed, for a first approximation to which the law would be

$$\frac{p\sqrt{h}+A\left(1-B\frac{\sqrt{h}}{p}\right)}{L} \quad . \quad . \quad . \quad . \quad . \quad (2)$$

constant, where A and B are constants to be determined by experiments.

Since the comparative periods of the two tanks have been made proportional to the square roots of their dimensions, e.g., the period of tank A $\sqrt{2}$ times the period of tank B, the bottom resistances produce dynamically similar results.

In comparing the results obtained with the same values of h in the same tank with different periods, the bottom resistances would be different, and this difference should appear in the results unless too small to be appreciable, in which case the results would compare with the simple period.

There are four other sources of possible divergence from the simple dynamic law, which will become larger as the periods become slower and the tide lower:—

1. The drainage of the sand after the tide has left it supplies the low water channels with a constant stream at low water; the velocity of this

stream will depend on the slope and quantity supplied, and supposing the quantity to be proportional to hL^2, the depth of the water in the low water channels (not the depth of the channels) will be proportional to the cube root of the slope;

2. The size of the grains of sand, which require a certain velocity before they move;

3. The fouling of the sand by growth, &c., which increases as the shifting of the sand diminishes; and

4. The viscosity of the water, which causes a definite change in the internal motion of the water when the velocity falls below a point which is inversely proportional to the dimensions of the channel.

The effect of 1 would be confined to the channels; 2 and 3 would tend to diminish the rate of action; the 4th might seriously alter the rate of action at different parts of the estuary, and would also affect the appearance of the sand surface.

The ground so far covered by the experiments has been confined to one initial arrangement and to one height of tide in each tank, these being similar. Two periods have been tried in each tank, the relation between the periods in the different tanks being as the square roots of the dimensions. Six experiments have been started:

2 in tank A	with a period of	53	secs.
1 ,,	,, ,,	33	,,
2 in tank B	,, ,,	36·5	,,
1 ,,	,, ,,	23·3	,,

Of the two experiments started at 53 seconds in tank A the first was continued for 12,697 tides, and then for 3,589 tides at a period of 50 secs., and a survey made (Plan 1). It was then continued 7,815 tides at 65·1 secs., and plan 2 marked; it was then continued 17,750 with intermittent waves at a period of 60·6 secs., and a survey made.

It was then continued for 12,705 tides at periods varying from 33 secs., having a mean 43, and Plan 4 made, then continued at a period of 33·3 secs. with intermittent waves, when it was re-surveyed (dotted on Plan 4).

The second experiment at 53, tank A, was continued to 8,700 tides with the same results as the first.

Of the two experiments in tank B the first was continued to 11,013 tides as in A, then stopped. The second was continued to 12,058 tides at 36·8 secs.; then at 4,280 tides at 36 secs., and surveyed (Plan 1 B); then continued to 6,769 more tides at 36, and again surveyed.

The experiments started at 33, tank A, and 23·3, tank B, were continued to 16,603 tides and then surveyed (Plans 7 A, 3 B).

In all these six experiments the manner in which the water commenced and proceeded to redistribute the sand was essentially the same, the general appearances of the surface being, with the exception of one or two particulars, the same at the same number of tides up to 1,200. After this the two low-speed experiments in B began to present more noticeable differences from the other experiments, which continued to present similar appearances at corresponding tides to the end.

It thus appeared:—

1. That the rate of action was proportional to the number of tides;

2. That the first result of the tide-way was to arrange the sand in a

continuous slope, gradually diminishing from high-water to a depth about equal to the tide below low-water;

3. That the second action was to groove this beach into banks and low-water channels, which attained certain general proportions (plans 5 and 7 A and 2 B, and cross sections);

4. That the slope arrived at after 16,000 tides was the same at the high speed in both models working at corresponding periods, $\sqrt{2}$ to 1 (section 3 A and 3 B);

5. That in both models the steepness of the actual slope increased as the tidal period diminished (section 5 and 7 A and 2 and 3 B).

Owing to the grooving of the surface the exact slopes at the various speeds cannot be exactly compared. One way of effecting a comparison has been to take the highest points on each cross section down the slope, and plot them as a longitudinal section, and in the same way to take the lowest points and plot them as another. These are shown in the two longitudinal sections which accompany each plan.

The increase of the slope with the diminution of the tidal period, both as regards the banks and channels, is thus rendered apparent; but these sections do not admit of an accurate comparison.

Some definite and accurate method of comparing these slopes was essential before any definite conclusions could be arrived at respecting the laws of similarity. To meet this the areas above the successive contours have been taken out. These areas respectively divided by the breadth of the plan give the mean distance of the respective contours from the head of the estuary, and the heights of these contours plotted to this mean distance give a definite mean slope of the sand. There are certain minor objections to this method, but it is eminently definite and practical, and admits of great accuracy, the areas being readily taken out with a planimeter with very great accuracy even for the most complicated contours. The slopes thus taken out are more readily compared if plotted to scales such that the vertical distances between high and low water are all equal, the horizontal scales being determined so that the vertical exaggeration is the same in all cases.

The slopes thus taken out from 5 A (Plans I. and IV.; Plates III. and VI.), 7 A (Plate VIII.), and from 3 B (Plate IX.) are shown in fig. 1, Plate II. They present a great degree of regularity; and it is seen at once that the results of corresponding periods (33 secs. tank A, and 23 secs. tank B) agree very closely.

In order to compare the slopes with the conditions of kinetic similarity, all that is necessary is to reduce the horizontal distances in the inverse ratio of the periods, when the slopes should become identical. In doing this the horizontal distances have all been reduced to represent (according to the kinetic law) a 30-feet tide with the natural period 44,400 seconds, namely, the ratio of the lengths of the estuaries made equal to the ratio of the periods multiplied by the square root of the ratio of the heights. The actual rise and fall of the tide in the models being taken:—

The horizontal and vertical scales for the five experiments as thus reduced to a 30-feet tide are given in Table I.

Table II. shows the measured height from low water for each of the contours, together with its mean distance from the contour at the height which reduced is 30 feet above low water. Also the corresponding heights of the contours of the 30-feet natural tide, and the corresponding

TABLE I.

Reference	Period in Seconds	Horizontal Scale	Inches to Mile	Vertical Scale	Rise of Tide
V. A, Plan 1 . .	50	{·0000862 / 1 in 11,600}	5·45	{·00587 / 1 in 170}	·176
V. A, Plan 4 . .	33·3	{·000055 / 1 in 18,200}	3·49	{·00533 / 1 in 187}	·161
VII. A, Plan 1 . .	33·6	{·000056 / 1 in 17,900}	3·55	{·0055 / 1 in 182}	·165
II. B, Plan 1 . .	35·4	{·0000431 / 1 in 23,200}	2·72	{·00293 / 1 in 341}	·088
III. B, Plan 1 . .	23·7	{·0000299 / 1 in 33,400}	1·895	{·00313 / 1 in 317}	·094

mean distances of the contours measured in miles, from which the curve of reduced mean slopes shown in fig. 2, Plate II., have been plotted.

Considering the character of the investigation, the agreement between the slopes is quite as close as could be expected, and there is nothing to argue from the divergences except that the effect of the bottom resistances has here been too small to affect the results.

The Length of the Foreshore.—The interval between mean high and low water, about 12·5 miles according to the kinetic scale for a 30-feet tide, cannot readily be compared with any actual case, since there are no sandy foreshores subject to a 30-feet tideway except those which are in a seaway and subject to longitudinal currents, while in the deep bays and mouths of estuaries, slopes are cut up with low-water channels besides a want of regularity in the lateral boundaries. In such bays as Morecambe Bay, Lynn deeps, and Solway Frith, the mean distance from the shore to the foot of the sands at low water must be 8 or 10 miles, and even taking this as the actual length it leaves no great margin for the resistance of the bottom, which would be 50 or 100 times greater in the actual case than with a model with a distortion of 50 or 100 times.

The only divergences of importance occur at the top and bottom of the slopes. That at the bottom of the curve for Experiment 5 A, Plan 1, is probably owing to the proximity of the generator, as in this plan the survey was continued to the end of the pan.

Such results, with regard to low-water channels, as have been obtained from the experiments already made are not discussed in this report, because they have been incidental to the immediate purpose of the experiments; they have, however, been carefully recorded for future reference, The same might be said of the manner of action of the water on the sand, were it not that these experiments have revealed a part taken by one of these actions, the importance of which does not appear to have been hitherto observed. This is the action known as rippling of the sand. In these experiments this action is seen to play an essential part in determining the rate at which the distribution of the sand is effected, while the result of this action—the ripple marks—forms a most conspicuous feature in the final distribution, as seen on the plans, as well as at all preceding stages.

The ripple marks on the strands are too well known to need descrip-

TABLE II.

Measured Heights of Contours shown on the Plans	Tank A								
	Experiment V.						Experiment VII		
	Plan 1			Plan 4			Plan 1		
	Height (reduced to a 30-feet Tide) of Contours from L.W.	Mean Horizontal Distance of Contours from the Contour at 30 feet above L.W.	Horizontal Distances reduced to a 30-feet Tide	Heights (reduced to a 30-feet Tide) of Contours from L.W.	Mean Horizontal Distance of Contours from the Contour at 30 feet above L.W.	Horizontal Distances reduced to a 30-feet Tide	Heights (reduced to a 30 feet Tide) of Contours from L.W.	Mean Horizontal Distances of Contours from the Contour[2] at 30 feet above L.W.	Horizontal Distances reduced to a 30-feet Tide
Feet	Feet	Unit 6 inches	Miles	Feet	Unit 6 inches	Miles	Feet	Unit 6 inches	Miles
[1]	—	−·69	−·76	—	−·975	−1·65	—	−·93	−1·67
·176	30·	·00	0	30·	0	0	28·05	·25	·42
·146	24·9	·91	1·	24·39	·79	1·355	22·58	·99	1·67
·116	19·8	2·13	2·34	18·68	1·86	3·2	17·11	1·76	2·98
·086	14·62	4·29	4·7	13·0	2·96	5·07	11·64	3·65	6·18
·056	9·52	6·47	7·1	7·46	4·64	7·95	6·17	5·3	8·95
·026	4·43	9·26	10·15	1·87	6·63	11·38	0·70	7·36	12·44
−·004	−·68	11·51	12·52	−3·74	8·43	14·5	−4·77	9·07	15·37
−·034	−5·8	14·58	16·00	−9·35	10·30	17·8	−10·24	11·00	18·60
−·064	−10·9	19·41	21·3	−15·	12·17	21·6	−15·71	13·20	22·32
−·094	−16·	21·31	23·4	−20·8	13·60	23·4	—	—	—
−·124	—	—	—	−26·2	15·88	27·3	—	—	—

Measured Heights of Contours shown on the Plan	Tank B					
	Experiment II			Experiment III		
	Plan 1			Plan 1		
	Height (reduced to a 30-feet Tide) of Contours from L.W.	Mean Horizontal Distance of Contours from the Contour at 30 feet above L.W.	Horizontal Distances reduced to a 30-feet Tide	Height (reduced to a 30-feet Tide) of Contours from L.W.	Mean Horizontal Distance of Contours from the Contour at 30 feet above L.W.	Horizontal Distances reduced to a 30-feet Tide
Feet	Feet	Unit 3 inches	Miles	Feet	Unit 3 inches	Miles
[1]	—	−7·	—	—	−1·82	−2·88
·088	30·	0	—	30·	0	0
·073	24·9	·5	—	25·2	·73	1·16
·058	19·8	2·	—	20·5	1·50	2·37
·043	14·62	3·	—	15·7	2·20	3·49
·028	9·52	5·8	—	10·9	3·53	5·6
·013	4·43	9·	—	6·3	5·25	8·32
−·002	−·68	11·8	—	−1·36	7·06	11·2
−·017	−5·8	14·3	—	−3·4	9·24	14·61
—	—	—	—	−8·2	10·14	16·1
—	—	—	—	−13·	12·43	19·8

[1] The distances in this row are the mean of the contour at 30 feet from the ends of the tanks.

[2] It having been found that in measuring the heights which are shown on this plan the datum had been taken ·0106 feet below L.W., the mean distances in the table have been obtained by interpolation between the mean distances as obtained from the areas of the contours on the plan.

tion, and there is nothing surprising that similar ripple marks should appear in the beds of the models. But although presenting a very similar appearance, and being about of the same size, the ripple marks seen in all the plans are essentially different in their origin and in the position they take in the *régime* of the sand in the models from that held by the observed ripple marks on the shore sands. This last is caused by the alternating currents produced by the small swell running inshore, while that in model is produced by the alternating action of the tide. There may seem nothing remarkable in this, considering that these currents in magnitude and velocity are not dissimilar—but if the models are similar to the results obtained in estuaries the converse should hold, and the estuaries should be similar to the models. In which case we are face to face with a very striking conclusion, that in the estuaries there should be—call it ripple mark or wave mark, produced by the action of the tide, similar to that on the models and on a scale proportional to the height of tide in the estuary. Thus some of the ripples in the models are from hollow to crest as much as one-fourth the mean rise of the tide, the distance between them being 12 times their height. This, in an estuary, would mean 7 or 8 feet high and 80 to 100 feet in distance.

These ripples in the model are almost confined to the surface of the sand which is below low-water mark, though in places their somewhat eroded ends protrude up the slope from the low-water channels. The existence of these ripples very much enhances the effect of the water to shift the sand—this was noted in the experiments 2 and 3 on the bars, tank A; on the smooth walls of the sand the current, which would be about 6 inches a second, did not drift the sand at all except close to the ridge, and then there was no apparent effect till after 1,700 tides, when ripples were just beginning, yet when the ripple once formed in another 1,200 tides the top of the bar had spread to 12 inches.

The ripples also serve to show in which way any shift of the sand is taking place, as they have a steep side looking in the direction of motion, and when the slopes are equal it is an indication of equilibrium.

Conclusions.—So far as these experiments have gone they have shown that similar results as to the general slope and rate of action of the sand can be obtained by models working according to the kinetic law as low as tides of

1 inch, with a vertical exaggeration of 100, or
2 inches ,, ,, ,, 64.

They have not shown, however, that the limit has been reached. Although the results obtained with a tide of 1 inch with a vertical exaggeration of 64 in tank B presented peculiarities which appeared in two experiments, it is still open to question whether these might not have been owing to something in the initial circumstances. This first series is therefore yet incomplete; it should include experiments to show the smallest vertical exaggeration at which similar results can be obtained with tides as small as half an inch and as large as 2 inches. This would give the law of the limits; this would conclude the first series. Then, if the experiments are continued, another series might be undertaken to determine whether similar effects can be obtained from land water acting on such slopes as have been already obtained; and again, as to the law of slopes and cross sections on V-shaped estuaries, and then, though this has been already established in my previous experiment, as to the effects of irregular lateral configuration in the shores.

Report of the Committee, consisting of Professor McLeod (*Chairman*), Professor Roberts-Austen (*Secretary*), *and* Professor Reinold, *for the Continuation of the Bibliography of Spectroscopy.*

PAPERS CONNECTED WITH SPECTRUM ANALYSIS.

Continuation of List published in Report for 1884.

INSTRUMENTAL.

1883.

E. J. Chapman .	Note on Spectroscopic Scales. (Read May 25.)	'Proc. and Trans. Roy. Soc. Canada,' i. Sect. III. 1883, 55–56.
E. Lommel . .	Spectroskop mit phosphorescirendem Ocular; Beobachtungen über Phosphorescenz. (Read Nov. 3.)	'Sitzungsb. Münchener Akad.' 1883, xiii. 408–422; 'Sitzungsb. phys.-med. Soc. Erlangen,' No. 16, 1–12 (Read Nov. 20); 'Ann. Phys. u. Chem.' N.F. xx. 847–860; 'Zeitschr. anal. Chem.' xxiii. 520 (Abs.); 'Zeitschr. f. Instrumentenkunde,' iv. 174–175 (Abs.)

1884.

W. N. Hartley .	A simple Method of Observing Faint Lines with Diffraction Spectroscopes. (Read Jan. 21.)	'Proc. Roy. Soc. Dublin,' N.S. iv. 206; 'Nature,' xxix. 470 (Abs.); 'Beiblätter,' viii. 767 (Abs.)
H. H. Hoffert . .	On a new Apparatus for Colour-Combinations. (Read June 14.)	'Proc. Phys. Soc.' vi. 200–204; 'Phil. Mag.' [5] xviii. 81–85; 'Zeitschr. f. Instrumentenkunde,' v. 28–29 (Abs.); 'Beiblätter,' ix. 342 (Abs.)
E. von Gothard .	Über ein neues Spectroskop. (Read Nov. 12.)	'Math. Naturwiss. Ber. Ungarn,' ii. 263–266; 'Beiblätter,' xi. 35 (Abs.)
E. Demarçay . .	Sur quelques procédés de spectroscopie pratique. (Read Dec. 8.)	'C. R.' xcix. 1022–1024; 'Ber.' xviii. Referate, 2 (Abs.); 'Beiblätter,' ix. 257–258 (Abs.); 'Les Mondes' [3] ix. 734–737 (Abs.)
" . .	Sur quelques procédés de spectroscopie pratique. (Read Dec. 15.)	'C. R.' xcix. 1069–1071; 'Chem. News,' li. 23–24 (Abs.); 'Am. J.' [3] xxix. 167 (Abs.); 'Ber.' xviii. Referate, 46 (Abs.); 'Les Mondes' [3] ix. 734–737 (Abs.)

1885.

E. von Gothard .	Ein Spektroskop mit elektrischer Beleuchtung und ein Universal Stativ für Telespektroskope.	'C. Z. f. Opt. u. Mech.' vi. 1–3.

INSTRUMENTAL, 1885.

O. Lohse . .	Beschreibung eines Spectrographen mit Flüssigkeitsprisma.	'Zeitschr. f. Instrumentenkunde,' v. 11–13; 'Beiblätter,' ix. 167 (Abs.)
J. Walter . .	Handregulator für electrisches Licht, zur Projection der Spectra.	'J. pr. Chem.' xxxi. 116–119; 'Beiblätter,' ix. 488 (Abs.); 'Zeitschr. f. Instrumentenkunde,' v. 249 (Abs.)
H. Draper . .	On the use of Carbon bisulphide in prisms, being an account of Experiments made by the late Dr. Henry Draper of New York.	'Am. J.' [3] xxix. 269–277; 'Nature,' xxxii. 272–273 (Abs.); 'Beiblätter,' ix. 420 (Abs.); 'J. Chem. Soc.' xlviii. 853 (Abs.)
C. V. Zenger . .	Études spectroscopiques. (Read March 9.)	'C. R.' c. 731–733; 'Beiblätter,' ix. 420 (Abs.)
E. Cleminshaw .	Lecture-Experiments on Spectrum Analysis. (Read March 14.)	'Proc. Phys. Soc.' vii. 51–55; 'Phil. Mag.' [5] xix. 365–368; 'Ber.' xviii. Referate, 406 (Abs.); 'Beiblätter,' ix. 517 (Abs.); 'J. Chem. Soc.' xlviii. 1035 (Abs.)
E. Lommel . .	Ueber einige optische Methode und Instrumente.	'Zeitschr. f. Instrumentenkunde,' v. 124–126; 'Beiblätter,' ix. 667–668 (Abs.)
Lord Rayleigh .	A Monochromatic Telescope, with Application to Photometry. (Read April 25.)	'Proc. Phys. Soc.' vii. 90–92; 'Phil. Mag.' [5] xix. 446–447; 'Chem. News,' li. 212 (Abs.); 'Beiblätter,' ix. 432 (Abs.)
E. v. Fleischl . .	Das Spectro-Polarimeter . .	'Repert. der Phys.' xxi. 323–331; 'Zeitschr. f. Instrumentenkunde,' v. 324 (Abs.); 'Beiblätter,' ix. 634–635 (Abs.)
M. de Thierry .	Sur un nouvel appareil dit hémaspectroscope. (Read May 11.)	'C. R.' c. 1244–1246; 'Ber.' xviii. Referate, 387 (Abs.); 'Chem. News,' li. 310–311 (Abs.)
E. Demarçay . .	Sur la production d'étincelles d'induction de températures élevées et son application à la spectroscopie. (Read May 18.)	'C. R.' c. 1293–1295; 'Chem. News,' li. 311 (Abs.); 'Beiblätter,' ix. 598 (Abs.)
J. Macé de Lépinay	Applications des spectres cannelés de Fizeau et Foucault.	'J. de Phys.' [2] iv. 261–271.
H. Krüss . .	Ueber Spectral-Apparate mit automatischer Einstellung.	'Zeitschr. f. Instrumentenkunde,' v. 181–191, 232–244; 'Beiblätter,' ix. 628–629 (Abs.)
G. Govi . . .	Spettroscopio a visione diretta, senza prismi nè reticoli. (Read June 13.)	'Rend. Accad. Sci. phys. e math. Naples,' xxiv. 139–141; 'C. R.' ci. 635 (Abs.); 'Chem. News,' lii. 201 (Abs.); 'Beiblätter,' x. 28–29 (Abs.)

INSTRUMENTAL, 1885, 1886.

W. de W. Abney .	The Production of Monochromatic Light, or a Mixture of Colours, on the Screen. (Read June 27.)	'Proc. Phys. Soc.' vii. 181–185; 'Phil. Mag.' [5] xx. 172–174; 'Nature,' xxxii. 263 (Abs.); 'Chem. News,' lii. 22 (Abs.); 'Beiblätter,' x. 169 (Abs.); 'Zeitschr. f. Instrumentenkunde,' vi. 212–213 (Abs.)
D. Draper . .	On Bisulphide of Carbon Prisms. (May 27. Read July 6.)	'Proc. Roy. Soc. Edinb.' xiii. 266–268.
C. V. Zenger . .	Nouveau spectroscope stellaire. (Read Sept. 21.)	'C. R.' ci. 616–618; 'Beiblätter,' x. 621 (Abs.)
J. Freyberg . .	Ueber ein verbessertes Spectrometer.	'Zeitschr. f. Instrumentenkunde,' v. 345–347; 'Beiblätter,' x. 105 (Abs.)
M. de Thierry . .	Sur un nouveau spectroscope d'absorption. (Read Oct. 26.)	'C. R.' ci. 811–813; 'J. Chem. Soc.' l. 113 (Abs.)
C. V. Zenger . .	Sur un optomètre spectroscopique. (Read Nov. 16.)	'C. R.' ci. 1003–1005; 'Am. J.' [3] xxxi. 60–61 (Abs.); 'Beiblätter,' x. 169 (Abs.)
C. V. Zenger . .	Spectroscope pour les hauts fourneaux et pour le procédé Bessemer. (Read Nov. 16.)	'C. R.' ci. 1005; 'Chem. News,' lii. 279 (Abs.); 'Beiblätter,' x. 169 (Abs.)
A. E. Bostwick .	A new form of Absorption Cell .	'Am. J.' [3] xxx. 452; 'Phil. Mag.' [5] xxi. 80; 'Beiblätter,' x. 289 (Abs.)
E. Linnemann .	Ueber ein neues Leuchtgas-Sauerstoffgebläse und das Zirkonlicht. (Read Dec. 3.)	'Sitzungsb. Wien. Akad.' xcii. II. 1248–1257; 'Monatsh. f. Chem.' vi. 899–908; 'Ber.' xix. Referate, 133–134 (Abs.); 'Zeitschr. f. Instrumentenkunde,' vi. 179–181 (Abs.); 'Beiblätter,' x. 570 (Abs.)
J. N. Lockyer .	A new form of Spectroscope. (Recd. Dec. 5. Read Dec. 17.)	'Proc. Roy. Soc.' xxxix. 416–417; 'Nature,' xxxiii. 189; 'Beiblätter,' x. 497 (Abs.)
B. Hasselberg .	Ueber die Anwendung von Schwefelkohlenstoffprismen zu spectroskopischen Beobachtungen von hoher Präcision. (Dec. 1885.)	'Ann. Phys. u. Chem.' N. F. xxvii. 415–435.

1886.

E. v. Gothard . .	Apparate für Aufnahmen himmlischer Objecte.	'Zeitschr. f. Instrumentenkunde, vi. 5–14.
E. Wiedemann .	Note au sujet d'un mémoire de M. Lagarde.	'Ann. Chim. et Phys.' [6] vii. 143–144; 'Am. J.' [3] xxxi. 218 (Abs.)
J. Reinke . .	Die Methode des Spectrophors .	'Ann. Phys. u. Chem.' N. F. xxvii. 444–448; 'Zeitschr. f. Instrumentenkunde,' vi. 212 (Abs.)

INSTRUMENTAL, 1886, 1887.

K. W. Zenger . .	Neues geradsichtiges Spectroskop ohne Spalt und ohne Collimatorlinse.	'Zeitschr. f. Instrumentenkunde,' vi. 59–61; 'Zeitschr. anal. Chem.' xxv. 379 (Abs.)
— Rosenberger .	Appareil optique universel. (In Russian.)	'J. soc. phys.-chim. russe,' xviii. 168–172; 'Beiblätter,' xi. 33 (Abs.)
B. Hecht . .	Ueber Prismen, welche zur Bestimmung von Brechungsindices durch Totalreflexion dienen sollen. (April 1.)	'Neues Jahrb. f. Mineral.' 1886, ii. 186–191; 'Beiblätter,' xi. 91 (Abs.)
J. E. A. Steggall .	A New Spectrometer . . .	'Nature,' xxxiv. 92–93.
G. F. M. Fielding .	Flame Spectra. (Sept. 1.) . .	'Chem. News,' liv. 212.
G. A Milne . .	Flame Spectra. (Oct. 25.) . .	'Chem. News,' liv. 225.
G. Krüss . .	Ueber einen Universalspectralapparat für qualitative und quantitative chemische Analyse. (Read Oct. 25.) . . .	'Ber.' xix. 2739–2745; 'Am. J.' [3] xxxiii. 67 (Abs.); 'Beiblätter,' xi. 339 (Abs.); 'Zeitschr. f. Instrumentenkunde,' vii. 182–183 (Abs.)
Stroumbo . .	Sur la recomposition de la lumière blanche à l'aide des couleurs du spectre. (Read Oct. 26.)	'C. R.' ciii. 737–738; 'Nature,' xxxv. 23 (Abs.); 'Chem. News,' liv. 250 (Abs.); 'J. Chem. Soc.' lii. 1 (Abs.)
C. Pulfrich . .	Ein neues Totalreflectometer. (I. Mittheilung.) (Oct. 1886.)	'Zeitschr. f. Instrumentenkunde,' vii. 16–29.
B. Kolbe . .	Modification der Mach'schen optischen Kammer und des Bunsen'schen Photometers, um sie zu Demonstrationen geeigneter zu machen. (Oct. 1886.)	'Zeitschr. f. Instrumentenkunde,' vii. 77–83; 'Beiblätter,' xi. 535-536 (Abs.)
C. Pulfrich . .	Das Krystallrefractoskop, ein Demonstrationsinstrument. (Nov. 1886.)	'Ann. Phys. u. Chem.' N.F. xxx. 317–319.
G. D. Liveing and J. Dewar . .	Note on a New Form of Direct Vision Spectroscope. (Recd. Nov. 18. Read Dec. 9.)	'Proc. Roy. Soc.' xli. 449–452.
C. Pulfrich . .	Das Totalreflectometer und seine Verwendbarkeit für weisses Licht. (II. Mittheilung.) (Dec. 1886.)	'Zeitschr. f. Instrumentenkunde,' vii. 55-65.
J. Seyffart . .	Dispersionspolarimeter . . .	'Dingler's polyt. Journ.' cclx. 222–224; 'Zeitschr. f. anal. Chem.' xxvi. 618 (Abs.)

1887.

W. Zenker . .	Das Fransen-Spectroskop, ein Apparat zur Herstellung von Interferenzerscheinungen im Spectrum und zur Messung der Gangunterschiede von Lichtstrahlen.	'Zeitschr. f. Instrumentenkunde,' vii. 1–7; 'Beiblätter,' xi. 442 (Abs.)
C. Pulfrich . .	Das Totalreflectometer. (III. Mittheilung.) (March, 1887.)	'Ann. Phys. u. Chem.' N.F. xxxi. 724–733.

INSTRUMENTAL, 1887, 1888, and 1889.

W. von Bezold	Ueber eine neue Methode zur Zerlegung des weissen Lichtes in Complementärfarben. (May, 1887.)	'Ann. Phys. u. Chem.' N.F. xxxii. 165-167.
C. C. Hutchins	A New Photographic Spectroscope. (June 3.)	'Am. J.' [3] xxxiv. 58-59; 'Phil. Mag.' [5] xxiv. 223-224 (Abs.); 'Beiblätter,' xii. 46 (Abs.)
H. Krüss	Repetitions-Spectrometer und Goniometer.	'Zeitschr. f. Instrumentenkunde,' vii. 215-218.
A. Raps	Ein Spectrometer verbesserter Construction.	'Zeitschr. f. Instrumentenkunde,' vii. 269-271.
C. Pulfrich	Nachtrag zur Abhandlung: Ein neues Totalreflectometer. (III. Mittheilung.) (Aug. 1887.)	'Zeitschr. f. Instrumentenkunde,' vii. 392-396.
J. Evershed, jun.	The Chromosphere	'Nature,' xxxvii. 79; 'Beiblätter,' xii. 663 (Abs.)
E. F. J. Love	On a Method of Discriminating Real from Accidental Coincidences between the Lines of different Spectra; with some Applications. (Read Nov. 26.)	'Proc. Phys. Soc.' ix. 94-100; 'Phil. Mag.' [5] xxv. 1-6; 'J. Chem. Soc.' liv. 542-543 (Abs.); 'Beiblätter,' xii. 348-349 (Abs.); 'J. Chem. Soc.' liv. 542-543 (Abs.)
	1888.	
C. Pulfrich	Ein neues Refractometer, besonders zum Gebrauch für Chemiker eingerichtet.	'Zeitschr. f. Instrumentenkunde,' viii. 47-53; 'Beiblätter,' xii. 333-334 (Abs.)
H. W. Vogel	Spectroskopische Notizen. (Recd. June 14. Read June 25.)	'Ber.' xxi. 2029-2032; 'Beiblätter,' xii. 786-787 (Abs.); 'J. Chem. Soc.' liv. 1129 (Abs.)
H. Krüss	Automatisches Spektroskop mit festem Beobachtungsfernrohr.	'Zeitschr. f. Instrumentenkunde,' viii. 388-392; 'Beiblätter,' xiii. 79 (Abs.)
	1889.	
J. Waterhouse	Photography of the Solar Spectrum. (Jan. 7.)	'Phil. Mag.' [5] xxvii. 284.
P. Schottländer	Vorschlag zur Abänderung des Spektroskops zur Bestimmung der Extinktionskoefficienten absorbirender Körper nach Vierordt's Methode. (Jan. 1889.)	'Zeitschr. für Instrumentenkunde,' ix. 98-101.
J. S. Ames	The Concave Grating in Theory and Practice. (March 27.)	'Phil. Mag.' [5] xxvii. 369-384.
G. Hufner	Über ein neues Spektrophotometer. (April, 1889.)	'Zeitschr. für physikal. Chem.' iii. 562-571.

EMISSION SPECTRA.

	1881.	
L. Palmieri . .	Intorno ad alcune incompatibilità spettroscopiche. (Read Nov. 12)	'Rend. Acc. di Napoli,' xx. 232-233; 'Beiblätter,' vi. 877 (Abs.); 'Zeitschr. anal. Chem.' xxii. 235-236 (Abs.); 'Chem. News,' xlvii. 247 (Abs.)
J. Levison . .	Spectrum of Light from Fireflies .	'Scientific American,' 1881, 184; 'Chem. Zeitung,' 1881, 774; 'Beiblätter,' v. 870 (Abs.); 'Nature,' xxv. 277 (notice).
	1883.	
Becquerel . .	Spectres d'émission infra-rouges des vapeurs métalliques. (Read July 9.)	'C. R.' xcvii. 71-74; 'Nature,' xxix. 227 (Abs.)
W. N. Hartley .	Report of Committee on Ultraviolet Spark Spectra. (Sept. 21.)	'Brit. Assoc. Report,' 1883, 127-132; 'Beiblätter,' vi. 537 (Abs.)
Auer von Welsbach	Über die Erden des Gadolinits von Ytterby. II. Abhandlung. (Read Dec. 20.)	'Sitzungsb. Wien. Akad.' lxxxviii. II. 1237-1251; 'Monatshefte,' v. 1-15; 'Zeitschr. anal. Chem.' xxiii. 520 (Abs.); 'Chem. News,' li. 25 (Abs.); 'Zeitschr.' f. Instrumentenkunde,' iv. 429-430 (Abs.)
S. Santini . .	Colorazione della fiamma d'idrogeno. (Dec. 27.)	'Gazz. chim. ital.' xiv. 142-147; 'J. Chem. Soc.' xlviii. 209 (Abs.)
	1884.	
N. v. Konkoly .	Astrophysikalische Beobachtungen, angestellt auf der Sternwarte Ó-Gyalla im Jahre 1883. Spectralanalytische und spectralphotometrische Untersuchungen einiger Kohlenhydrogengase bei variablen Drucke. (Read May 20.)	'Math.-naturwiss. Ber. Ungarn,' ii. 202-203.
K. N. Kronstchoff .	Sur l'analyse spectrale appliquée aux études micromineralogiques. (Read July 10.)	'Bull. Soc. Min. de France,' vii. 243-249.
S. Santini . .	Seguito dello studio sulla colorazione della fiamma dell' idrogeno. (July 1884.)	'Gazz. chim. ital.' xiv. 274-276; 'Beiblätter,' ix. 32 (Abs.); 'J. Chem. Soc.' xlviii. 465 (Abs.)
H. Becquerel .	Spectres d'émission infra-rouges des vapeurs métalliques. (Read Aug. 25.)	'C. R.' xcix. 374-376; 'Phil. Mag.' [5] xviii. 386-389; 'Am. J.' [3] xxviii. 459-461; Chem. News,' l. 127 (Abs.); 'J. Chem. Soc.' xlvi. 1237 (Abs.); 'Beiblätter,' viii. 819-820 (Abs.)
G. D. Liveing and J. Dewar.	On the Spectral Lines of the Metals developed by Exploding Gases.	'Phil. Mag.' [5] xviii. 161-173; 'J. Chem. Soc.' xlviii. 317-318 (Abs.)

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R. Thalén	Sur le spectre du fer obtenu à l'aide de l'arc électrique. (Read Sept. 26.)	'Upsala. Nova Acta Kongl. Vetensk. Soc.' [3] xii. 1–49; 'Nature,' xxxii. 253 (Abs.); 'Beiblätter,' ix. 520–521 (Abs.).
B. Hasselberg	Zur Spectroskopie des Stickstoffs. (Read Oct. 23.)	'Mém. Acad. S. Pétersb.' [7] xxxii. No. 15, pp. 50; 'Beiblätter,' ix. 578 (Abs.)
M. C. Traub and C. Hock.	Ueber ein Lakmoid. (Recd. Nov. 12. Read Nov. 24.)	'Ber.' xvii. 2615–2617.
B. Hasselberg	Zusatz zu meinen Untersuchungen über das zweite Spectrum des Wasserstoff. (Read Dec. 18.)	'Bull. de l'Acad. St. Pétersbourg,' xxx. 14–21; 'Beiblätter,' ix. 519–520 (Abs.)

1885.

J. J. Balmer	Notiz über die Spektrallinien des Wasserstoffs.	'Verh. naturf. Ges. Basel,' vii. 548–560; 'Ann. Phys. u. Chem.' N.F. xxv. 80–87; 'J. Chem. Soc.' xlviii. 1025 (Abs.)
"	Zweite Notiz (Jan. 30.)	'Verh. naturf. Ges. Basel,' vii. 750–752.
A. F. Sundell	Researches on Spectrum Analysis. (May 26, 1885.)	'Phil. Mag.' [5] xxiv. 98–106; 'J. Chem. Soc.' lii. 1066 (Abs.)
W. Crookes	Sur la spectroscopie par la matière radiante. (Read June 2.)	'C. R.' c. 1380–1382; 'Chem. News,' lii. 23 (Abs.); 'Beiblätter,' ix. 579–580 (Abs.)
Lecoq de Boisbaudran.	Sur un nouveau genre de spectres métalliques. (Read June 8.)	'C. R.' c. 1437–1440; 'Nature,' xxxii. 285–286; 'Chem. News,' lii. 4–5; 'Ber.' xviii. Referate, 426–427 (Abs.); 'J. Chem. Soc.' xlviii. 949 (Abs.); 'Beiblätter,' x. 172 (Abs.)
F. Lucas	Radiations émises par les charbons incandescents. (Read June 8.)	'C. R.' c. 1454–1456.
W. Crookes	Sur la spectroscopie par la matière radiante. Extinction mutuelle des sprectres d'yttrium et de samarium. (Read June 15.)	'C. R.' c. 1495–1497; 'Chem. News,' lii. 46–47 (Abs.); 'J. Chem. Soc.' xlviii. 1025–1026 (Abs.); 'Ber.' xviii. Referate, 491 (Abs.); 'Beiblätter,' x. 171–172 (Abs.)
"	On Radiant Matter Spectroscopy. Part II. Samarium. (Recd. May 21. Read June 18.)	'Phil. Trans.' clxxvi. 691–723; 'Proc. Roy. Soc.' xxxviii. 414–422 (Abs.); 'Nature,' xxxii. 283–285 (Abs.); 'Chem. News,' liv. 28–31, 40–43, 54–57, 63–66, 76–78; 'Ber.' xix. Referate, 736–738 (Abs.)

EMISSION SPECTRA, 1885, 1886.

Lecoq de Boisbaudran.	Spectre de l'ammoniaque par renversement du courant induit. (Read July 6.)	'C. R.' ci. 42–45; 'Chem. News,' lii. 58–59 (Abs.); lii. 276–277; 'J. Chem. Soc.' xlviii. 1025 (Abs.); 'Ber.' xviii. Referate, 492 (Abs.); 'Beiblätter,' x. 171 (Abs.)
E. Becquerel . .	Étude spectrale des corps rendus phosphorescents par l'action de la lumière ou par les décharges électriques. (Read July 20.)	'C. R.' ci. 205–210; 'Chem. News,' lii. 76–78; 'Beiblätter,' x. 54 (Abs.)
E. Hoppe . .	Das Spectrum des Büschellichtes. (Read Aug. 1.)	'Göttingen Nachr.' 1885, 305–310; 'Beiblätter,' x. 131–132 (Abs.)
Lecoq de Boisbaudran.	Sur la fluorescence des terres rares. (Read Sept. 7 and 14.)	'C. R.' ci. 552–555, 588–592; 'Chem. News,' lii. 290–291, 299–300; 'J. Chem. Soc.' xlviii. 1174–1175 (Abs.); 'Beiblätter,' x. 172, 173 (Abs.)
E. Linnemann .	Über ein neues Leuchtgas-Sauerstoffgebläse und das Zirkonlicht. (Read Dec. 3.)	'Sitzungsb. Wien. Akad.' xcii. II. 1248–1257; 'Monatsh. f. Chem.' vi. 899–908; 'Ber.' xix. Referate, 133–134 (Abs.); 'Zeitschr. f. Instrumentenkunde,' vi. 179–181 (Abs.); 'Beiblätter,' x. 570 (Abs.)
H. Deslandres .	Spectre de bandes de l'azote; son origine. (Read Dec. 14.)	'C. R.' ci. 1256–1260; 'Nature,' xxxiii. 192 (Abs.); 'Chem. News,' liii. 11 (Abs.); 'J. Chem. Soc.' l. 189 (Abs.); 'Beiblätter,' x. 356–357 (Abs.)

1886.

Lecoq de Boisbaudran.	Sur un spectre électrique particulier aux terres rares du groupe terbique. (Read Jan. 18.)	'C. R.' cii. 153–155; 'Chem. News,' liii. 63; 'J. Chem. Soc.' l. 293 (Abs.); 'Ber.' xix. Referate, 132–133 (Abs.)
W. Crookes . .	On Radiant Matter Spectroscopy; Note on the Spectra of Erbia. (Recd. Jan. 7. Read Jan. 21.)	'Proc. Roy. Soc.' xl. 77–79; 'Nature,' xxxiii. 474; 'Chem. News,' liii. 75–76; 'J. Chem. Soc.' l. 749 (Abs.)
Lecoq de Boisbaudran.	Sur l'équivalent des terbines. (Read Feb. 22.)	'C. R.' cii. 395–398; 'Chem. News,' liii. 121–122; 'J. Chem. Soc.' l. 424–425 (Abs.), 507 (Abs.)
W. Crookes . .	On Radiant Matter Spectroscopy: Note on the Earth Yα. (Recd. Feb. 18. Read Feb. 25.)	'Proc. Roy. Soc.' xl. 236–237; 'Chem. News,' liii. 133.

EMISSION SPECTRA, 1886.

W. Crookes . .	Sur les spectres de l'erbine. (Read March 1.)	'C. R.' cii. 506–507; 'Nature,' xxxiii. 450 (Abs.); 'Ber.' xix. Referate, 234 (Abs.); 'Beiblätter,' xi. 93 (Abs.)
" . .	Sur la terre Yα. (Read March 15.)	'C. R.' cii. 646–647; 'Nature,' xxxiii. 525; 'Ber.' xix. Referate, 234 (Abs.) 'J. Chem. Soc.' l. 506–507 (Abs.); 'Am. J.' [3] xxxii. 76 (Abs.)
T. S. Humpidge .	The Spectra of Erbia. (March 22.)	'Chem. News,' liii. 154–155.
W. N. Hartley .	The Spectra of Erbia.	'Chem. News,' liii. 179.
Lecoq de Boisbaudran.	Les fluorescences Zα et Zβ appartiennent-elles à des terres différentes? (Read April 19.)	'C. R.' cii. 899-902; 'Nature,' xxxiii. 623 (Abs.); 'Chem. News,' liii. 217–218; 'Ber.' xix. Referate, 333 (Abs.); 'J. Chem. Soc.' l. 666–667 (Abs.)
E. Linnemann .	Austrium, ein neues metallisches Element. (Read May 6.)	'Sitzungsb. Wien. Akad.' xciii. II. 662–664; 'Monatsh. f. Chem.' vii. 121–123; 'Wien. Anz.' 1886, 87–88 (Abs.); 'Ber.' xix. Referate, 431 (Abs.); 'J. Chem. Soc.' l. 773 (Abs.); 'Beiblätter,' x. 542 (Abs.); 'Am. J.' [3] xxxii. 405–406 (Abs.)
L. Bell . . .	The Ultra-violet Spectrum of Cadmium.	'Am. J.' [3] xxxi. 426–432; 'Nature,' xxxiv. 208 (Abs.); 'J. Chem. Soc.' l. 957–958 (Abs.); 'Beiblätter,' x. 699 (Abs.)
Lecoq de Boisbaudran.	Sur le poids atomique et sur le spectre du germanium. (Read June 7.)	'C. R.' cii. 1291–1295; 'Nature,' xxxiv. 163 (Abs.); 'Chem. News,' liv. 4–5 (Abs.); 'Ber.' xix. Referate, 479–480 (Abs.); 'J. Chem. Soc.' l. 768 (Abs.); 'Beiblätter,' x. 569 (Abs.)
W. Crookes . .	On some new Elements in Gadolinite and Samarskite, detected spectroscopically. (Recd. June 9. Read June 10.)	'Proc. Roy. Soc.' xl. 502–509; 'Nature,' xxxiv. 160–162; 'Chem. News,' liv. 13–15; 'Ber.' xix. Referate, 651–652 (Abs.); 'J. Chem. Soc.' lii. 334–335 (Abs.)
G. Kobb . . .	Ueber das Spectrum des Germaniums. (June 19.)	'Ann. Phys. u. Chem.' N.F. xxix. 670–671; 'J. Chem. Soc.' lii. 313–314 (Abs.); 'Am. J.' [3] xxxiii. 151 (Abs.)

EMISSION SPECTRA, 1886.

Lecoq de Boisbaudran.	Sur l'annonce de la découverte d'un nouveau métal, l'*austrium*. (Read June 21.)	'C. R.' cii. 1436; 'Nature,' xxxiv. 211 (Abs.); 'Chem. News,' liv. 23 (Abs.); 'Beiblätter,' x. 542 (Abs.); 'Ber.' xix. Referate, 650 (Abs.)
"	Sur la fluorescence anciennement attribuée à l'yttria. (Read June 28.)	'C. R.' cii. 1536–1539; 'Chem. News,' liv. 15–16; 'Nature,' xxxiv. 235 (Abs.); 'J. Chem. Soc.' l. 838 (Abs.); 'Ber.' xix. Referate, 649–650 (Abs.)
"	Identité d'origine de la fluorescence $Z\beta$ par renversement et des bandes obtenues dans le vide par M. Crookes. (Read July 12.)	'C. R.' ciii. 113–117; 'Nature,' xxxiv. 284 (Abs.); 'J. Chem. Soc.' l. 958 (Abs.); 'Ber.' xix. Referate, 650 (Abs.)
C. Winkler . .	Mittheilungen über das Germanium. (July 1886.)	'Journ. pr. Chem. [2] xxxiv. 177–229; 'Am. J. [3] xxxiii. 68–69 (Abs.); 'Chemiker Zeitung,' x. 1057; 'Chem. News,' liv. 136 (Abs.)
W. Crookes . .	What is Yttria?	'Chem. News,' liv. 39–40; 'J. Chem. Soc.' l. 853 (Abs.)
A. Cornu . .	Sur le spectre ultra-violet de l'hydrogène.	'J. de Phys.' [2] v. 341–354; 'Beiblätter,' xi. 582–583 (Abs.)
H. Deslandres .	Spectre du pôle négatif de l'azote. Loi générale de répartition des raies dans les spectres de bandes. (Read Aug. 9.)	'C. R.' ciii. 375–379; 'Chem. News,' liv. 100; 'Nature,' xxxiv. 380 (Abs.); 'J. Chem. Soc.' l. 957 (Abs.); 'Beiblätter,' xi. 36 (Abs.)
Lecoq de Boisbaudran.	Sur le poids atomique du germanium. (Read Aug. 30.)	'C. R.' ciii. 452–453; 'Nature,' xxxiv. 463 (Abs.); 'Beiblätter,' x. 569 (Abs.); 'J. Chem. Soc.' lii. 15 (Abs.)
E. Hagenbach-Bischoff.	Balmer'sche Formel für Wasserstofflinien.	'Verh. d. Naturforsch. Ges. zu Basel,' 1886, 242; 'Beiblätter,' xi. 339–340 (Abs.)
Lecoq de Boisbaudran.	Fluorescence des composés du manganèse, soumis à l'effleuve électrique dans le vide. (Read Sept. 6.)	'C. R.' ciii. 468–471; 'Nature,' xxxiv. 491 (Abs.); 'Chem. News,' liv. 165 (Abs.); 'Ber.' xix. Referate, 738–739 (Abs.); 'Beiblätter,' x. 702–703 (Abs.); xi. 37–38 (Abs.); 'J. Chem. Soc.' lii. 3–4 (Abs.); 'Am. J.' [3] xxxiii. 149–151 (Abs.)
W. Crookes . .	On the Fractionation of Yttria. (Brit. Assoc., Sept. 1886.)	'Chem. News,' liv. 155–158; 'Nature,' xxxiv. 584–587; 'Ber.' xix. Referate, 738 (Abs.)

EMISSION SPECTRA, 1886, 1887.

Lecoq de Boisbaudran.	Purification de l'yttria. (Read Oct. 11.)	'C. R.' ciii. 627–629; 'Nature,' xxxiv. 612 (Abs.); 'Chem. News,' liv. 225 (Abs.); 'Ber.' xix. Referate, 810 (Abs.); 'J. Chem. Soc.' lii. 13–14 (Abs.)
"	Fluorescence des composés du bismuth soumis à l'effleuve électrique dans le vide. (Read Oct. 11.)	'C. R.' ciii. 629–631; 'Nature,' xxxiv. 612 (Abs.); 'Chem. News,' liv. 225 (Abs.); 'Ber.' xix. Referate, 810–811 (Abs.); 'J. Chem. Soc.' lii. 4 (Abs.); 'Beiblätter,' xi. 39 (Abs.); 'Am J.' [3] xxxiii. 149–151 (Abs.)
G. Krüss . .	Untersuchungen über das Gold. II. Mittheilung. (Recd. Nov. 20.)	'Ann. der Chemie,' ccxxxviii. 30–77; 'J. Chem. Soc.' lii. 554–555 (Abs.); 'Beiblätter,' xi. 703–704 (Abs.)
Lecoq de Boisbaudran	Florescences du manganèse et du bismuth. (Read Nov. 29.)	'C. R.' ciii. 1064–1068; 'Ber.' xx. Referate, 4 (Abs.); 'J. Chem. Soc.' lii. 189–190 (Abs.); 'Am. J.' [3] xxxiii. 149–151 (Abs.); 'Beiblätter,' xi. 584 (Abs.)
"	Sur la fluorescence rouge de l'alumine. (Read Dec. 6.)	'C. R.' ciii. 1107; 'Nature,' xxxv. 168 (Abs.); 'Chem. News,' liv. 322 (Abs.); 'Ber.' xx. Referate, 5 (Abs.); 'J. Chem. Soc.' lii. 191 (Abs.); 'Am. J.' [3] xxxiii. 149–151 (Abs.); 'Beiblätter,' xi. 780–781 (Abs.)
. Becquerel . .	Sur la phosphorescence de l'alumine. (Read Dec. 20.)	'C. R.' ciii. 1224–1227; 'Chem. News,' lv. 23 (Abs.); 'J. Chem. Soc.' lii. 191 (Abs.); 'Am. J.' [3] xxxiii. 303–304 (Abs.); 'Beiblätter,' xi. 780–781 (Abs.)

1887.

W. Crookes . .	On the Crimson Line of Phosphorescent Alumina. (Recd. Dec. 30, 1886. Read Jan. 13, 1887.)	'Proc. Roy. Soc.' xlii. 25–31; 'Chem. News,' lv. 25–27; 'Nature,' xxxv. 310–311 (Abs.); 'Am. J.' [3] xxxiii. 304–305 (Abs.); 'J. Chem. Soc.' lii. 1006 (Abs.); 'Beiblätter,' xi. 782–783 (Abs.); 'Ber.' xxi. Referate, 276–277 (Abs.)

EMISSION SPECTRA, 1887.

Lecoq de Boisbaudran.	Sur la fluorescence rouge de l'alumine. (Read Feb. 7.)	'C. R.' civ. 330–334; 'Chem. News,' lv. 116 (Abs.); 'Ber.' xx. Referate, 135 (Abs.); 'J. Chem. Soc.' lii. 409 (Abs.); 'Beiblätter,' xi. 780–781 (Abs.)
E. Becquerel . .	Sur la phosphorescence de l'alumine. (Read Feb. 7.)	'C. R.' civ. 334–335; 'Chem. News,' lv. 99–100; 'J. Chem. Soc.' lii. 409–410 (Abs.); 'Beiblätter,' xi. 780–781 (Abs.)
W. Crookes . .	On Radiant Matter Spectroscopy:—Examination of the Residual Glow. (Recd. Feb. 10. Read Feb. 17.)	'Proc. Roy. Soc.' xlii. 111–131; 'Chem. News,' lv. 107–110, 119–121, 131–132; 'Nature,' xxxv. 425–428, 447–451; 'J. Chem. Soc.' lii. 1066–1069 (Abs.); 'Beiblätter,' xi. 781–782 (Abs.)
Lecoq de Boisbaudran.	Sur la fluorescence rouge de l'alumine. (Read Feb. 21.)	'C. R.' civ. 478–482; 'Nature,' xxxv. 431 (Abs.); 'Chem. News,' lv. 128 (Abs.); 'Ber.' xx. Referate, 192 (Abs.); 'J. Chem. Soc.' lii. 538–539 (Abs.); 'Beiblätter,' xi. 781 (Abs.)
,,	Sur la fluorescence rouge de l'alumine. (Read Feb. 28.)	'C. R.' civ. 554–556; 'Nature,' xxxv. 455 (Abs.); 'Chem. News,' lv. 140 (Abs.); 'Ber.' xx. Referate, 192 (Abs.); 'J. Chem. Soc.' lii. 538–539 (Abs.); 'Beiblätter,' xi. 781 (Abs.)
E. Demarçay . .	Sur les spectres des étincelles des bobines à gros fil. (Read March 7.)	'C. R.' civ. 678–679; 'Chem. News,' lv. 153 (Abs.); 'J. Chem. Soc.' lii. 537 (Abs.); 'Beiblätter,' xi. 703 (Abs.)
Lecoq de Boisbaudran.	Sur la fluorescence rouge de l'alumine. (Read March 21.)	'C. R.' civ. 824–826; 'Nature,' xxxv. 527 (Abs.); 'Chem. News,' lv. 176 (Abs.); 'Ber.' xx. Referate, 246–247 (Abs.); 'J. Chem. Soc.' lii. 625 (Abs.); 'Beiblätter,' xi. 781 (Abs.)
Deslandres . .	Loi de répartition des raies et des bandes, commune à plusieurs spectres de bandes. Analogie avec la loi de succession des sons d'un corps solide. (Read April 4.)	'C. R.' civ. 972–976; 'Nature,' xxxv. 576 (Abs.); 'Chem. News,' lv. 204–205 (Abs.)
Lecoq de Boisbaudran.	Fluorescence rouge de la galline chromifère. (Read June 6.)	'C. R.' civ. 1584–1585; 'Chem. News,' lvi. 12 (Abs.); 'Ber.' xx. Referate, 456 (Abs.); 'J. Chem. Soc.' lii. 755 (Abs.); 'Beiblätter,' xi. 786 (Abs.)

EMISSION SPECTRA, 1887.

Lecoq de Boisbaudran.	Fluorescences du manganèse et du bismuth. (Read June 13.)	'C. R.' civ. 1680–1685; 'J. Chem. Soc.' lii. 873 (Abs.); 'Beiblätter,' xi. 784–785 (Abs.)
"	Fluorescence du manganèse et du bismuth. (Read July 4.)	'C. R.' cv. 45–48; 'Nature,' xxxvi. 264 (Abs.); 'Ber.' xx. Referate, 533 (Abs.); 'J. Chem. Soc.' lii. 1006–1007 (Abs.); 'Beiblätter,' xi. 784–785 (Abs.)
"	Fluorescence du manganèse et du bismuth. Remarques ou conclusions. (Read July 25.)	'C. R.' cv. 206–208; 'Nature,' xxxvi. 336 (Abs.); 'Chem. News,' lvi. 90 (Abs.); 'Ber.' xx. Referate, 533 (Abs.); 'J. Chem. Soc.' lii. 1006–1007 (Abs.); 'Beiblätter,' xi. 784–785 (Abs.)
W. Crookes . .	Notes on the Group of Rare Earths, considered *à propos* of Mr. Crookes's Theory of the Genesis of the Elements.	'Chem. News,' lvi. 39–40.
Lecoq de Boisbaudran.	Nouvelles fluorescences, à raies spectrales bien définies. (Read Aug. 1.)	'C. R.' cv. 258–261; 'Nature,' xxxvi. 360 (Abs.); 'Chem. News,' lvi. 114 (Abs.); 'Ber.' xx. Referate, 533 (Abs.); 'J. Chem. Soc.' lii. 1008 (Abs.); 'Beiblätter,' xi. 786 (Abs.)
"	Fluorescence du spinelle. (Read Aug. 1.)	'C. R.' cv. 261–262; 'Nature,' xxxvi. 360 (Abs.) 'Chem. News,' lvi. 114 (Abs.); 'Ber.' xx. Referate, 533 (Abs.); 'J. Chem. Soc.' lii. 1005 (Abs.); 'Beiblätter,' xi. 781 (Abs.)
"	Nouvelles fluorescences à raies spectrales bien définies. (Read Aug. 8 and 16.)	'C. R.' cv. 301–304, 343–347; 'Nature,' xxxvi. 383 (Abs.), 408 (Abs.); 'Chem. News,' lvi. 139 (Abs.); 'Ber.' xx. Referate, 627 (Abs.); 'J. Chem. Soc.' lii. 1008 (Abs.); 'Beiblätter,' xi. 786 (Abs.)
W. Crookes .	On a Sharp Line Spectrum of Phosphorescent Alumina.	'Chem. News,' lvi. 59–62, 72–74; 'J. Chem. Soc.' lii. 1069–1070 (Abs.); 'Ber.' xxi. Referate, 277–278 (Abs.)
" . .	On Sharp Line Spectra of Phosphorescent Yttria and Lanthana.	'Chem. News,' lvi. 62, 81–82; 'J. Chem. Soc.' lii. 1070 (Abs.); 'Ber.' xxi. Referate, 278 (Abs.)

EMISSION SPECTRA, 1887, 1888.

Lecoq de Boisbaudran.	Nouvelles fluorescences à raies spectrales bien définies. (Read Oct. 31.)	'C. R.' cv. 784–788; 'Nature,' xxxvii. 47 (Abs.); 'Chem. News,' lvi. 259 (Abs.); 'Ber.' xx. Referate, 773 (Abs.); 'J. Chem. Soc.' liv. 97 (Abs.); 'Beiblätter,' xii. 196 (Abs.)
J. N. Lockyer .	Researches on the Spectra of Meteorites. A Report to the Solar Physics Committee. (Preliminary note recd. Oct. 4; Addendum recd. Nov. 15. Read Nov. 17.)	'Proc. Roy. Soc.' xliii. 117–156; 'Nature,' xxxvii. 55–61, 80–87; 'Beiblätter,' xii. 357 (Abs.); 'J. Chem. Soc.' liv. 638–639 (Abs.)
S. Meunier . .	Les météorites et l'analyse spectrale. (Read Nov. 28.)	'C. R.' cv. 1095–1097; 'Chem. News,' lvi. 279 (Abs.)
	1888.	
P. Simon . .	Une expérience de cours (a method of shewing that, when a body is heated, the rays it emits are a function of the temperature).	'J. de Phys.' [2] vii. 79–80; 'Phil. Mag.' [5] xxvi. 320.
G. D. Liveing and J. Dewar.	On the Spectrum of the Oxyhydrogen Flame. (Recd. Jan. 18. Read Feb. 2.)	'Phil. Trans.' clxxix. A. 27–42; 'Proc. Roy. Soc.' xliii. 347–348 (Abs.); 'Nature,' xxxvii. 383; 'J. Chem. Soc.' liv. 637 (Abs.); 'Chem. News,' lvii. 53; 'Ber.' xxi. Referate, 279 (Abs.); 'Beiblätter,' xii. 349–350 (Abs.), xiii. 216–217 (Abs.)
Lecoq de Boisbaudran.	À quels degrés d'oxydation se trouvent le chrome et le manganèse dans leurs composés fluorescents? (Read Feb. 13.)	'C. R.' cvi. 452–455.
H. Deslandres .	Détermination, en longueurs d'onde, de deux raies rouges du potassium. (Read March 12.)	'C. R.' cvi. 739; 'Nature,' xxxvii. 504 (Abs.); 'J. Chem. Soc.' liv. 637 (Abs.); 'Chem. News,' lvii. 140–141 (Abs.); 'Beiblätter,' xii. 854 (Abs.)
G. D. Liveing and J. Dewar.	On the Ultra-violet Spectra of the Elements. Part III. Cobalt and Nickel. (Recd. Feb. 27. Read March 15.)	'Phil. Trans.' clxxix. A. 231–256; 'Proc. Roy. Soc.' xliii. 430 (Abs.); 'J. Chem. Soc.' lvi. 89 (Abs.); 'Beiblätter,' xii. 582 (Abs.), xiii. 380–381 (Abs.)
N. Deslandres .	Spectre de bandes ultra-violet des composés hydrogénés et oxygénés du carbone. (Read March 19.)	'C. R.' cvi. 842–846; 'J. Chem. Soc.' liv. 637–638 (Abs.); 'Beiblätter,' xii. 854–855 (Abs.)

EMISSION SPECTRA, 1888, 1889.

E. Demarçay	Remarques sur quelques raies spectrales de l'or. (Read April 23.)	'C. R.' cvi. 1228–1229; 'J. Chem. Soc.' liv. 765–766 (Abs.); 'Chem. News,' lvii. 191 (Abs.); 'Beiblätter,' xii. 581–582.
Lecoq de Boisbaudran.	Observations	'C. R.' cvi. 1229–1230.
"	Fluorescence de la chaux cuprifère. (Read May 14.)	'C. R.' cvi. 1386–1387; 'Nature,' xxxviii. 95 (Abs.); 'Chem. News,' lvii. 220 (Abs.)
G. D. Liveing and J. Dewar.	Investigations on the Spectrum of Magnesium. No. II. (Recd. May 16. Read May 31.)	'Proc. Roy. Soc.' xliv. 241–252; 'Nature,' xxxviii. 165–167; 'J. Chem. Soc.' lvi. 89 (Abs.); 'Beiblätter,' xiii. 381–382 (Abs.)
J. Parry	The Practical Use of the Spectroscope.	'Industries,' v. 172, 210, 309, 533, 543.
Lecoq de Boisbaudran.	Fluorescence de la chaux ferrifère. (Read June 18.)	'C. R.' cvi. 1708–1710; 'Nature,' xxxviii. 216 (Abs.); 'Chem. News,' lviii. 12 (Abs.); 'J. Chem. Soc.' liv. 1001 (Abs.); 'Ber.' xxi. 599 (Abs.)
"	À quels degrés d'oxydation se trouvent le chrome et le manganèse dans leurs composés fluorescents? (Read June 25.)	'C. R.' cvi. 1781–1784; 'Nature,' xxxviii. 239 (Abs.); 'J. Chem. Soc.' liv. 1001 (Abs.); 'Ber.' xxi. Referate, 599 (Abs.)
"	À quels degrés d'oxydation se trouvent le chrome et le manganèse dans leurs composés fluorescents? (Read July 30, Sept, 3, 10.)	'C. R.' cvii. 311–314, 468–471, 490–494; 'Chem. News,' lviii. 170 (Abs.), 183 (Abs.); 'J. Chem. Soc.' liv. 1229 (Abs.), lvi. 2 (Abs.); 'Ber.' xxi. Referate, 705–706 (Abs.); 'Beiblätter,' xiii. 19 (Abs.)
Deslandres	Spectres des bandes ultra-violets des métalloides avec une faible dispersion.	'Ann. de Chim. et Phys.' [6], xv. 5–86.

1889.

Lecoq de Boisbaudran.	Sur le gadolinium de M. de Marignac. (Read Jan. 28.)	'C. R.' cviii. 165–168; 'J. Chem. Soc.' lvi. 455–456 (Abs.)
J. N. Lockyer	Notes on Meteorites.	'Nature,' xxxviii. 424–428, 456–458, 530–533; 556–559, 602–605; xxxix. 139–142, 233–236, 400–402.
W. Crookes	Recent Researches on the Rare Earths as interpreted by the Spectroscope. (Presidential Address, Chemical Society, March 21.)	'J. Chem. Soc.' lv. 255–285; 'Nature,' xxxix. 537–543; 'Chem. News,' lx. 27–30, 39–41, 51–53, 63–66.

EMISSION SPECTRA, 1889—ABSORPTION SPECTRA, 1882, 1883 and 1884.

Gouy . . .	Sur l'élargissement des raies spectrales des métaux. (Read June 17.)	C. R.' cviii. 1236–1238; 'Nature,' xl. 216 (Abs.); 'Chem. News,' lx. 8.

ABSORPTION SPECTRA.

1882.

C. H. Wolff . .	Einige neue Absorptionsspektren .	'Repert. anal. Chem. ii. 55–56; 'Zeitschr. anal. Chem.' xxii. 96–97 (Abs.)
G. Valentin . .	Die Orte und Breiten der Blutbänder.	'Zeitschr. f. Biol.' xviii. 173–219; 'Ber.' xvi. 92–93 (Abs.)
B. Brauner . .	Beitrag zur Chemie der Ceritmetalle. II. (Read June 15.)	'Sitzungsb. Wien. Akad.' lxxxvi. 168–185; 'Chem. Zeitung,' 1882, 959 (Abs.); 'Chem. News,' xlvi. 268 (Abs.)
J. S. Konic . .	Einige Bemerkungen über die Absorptionspectra der Körper der aromatische Reihe (Polnische wissensch. Jahrgänge, iii. 115–118). (In Polish.)	'Beiblätter,' viii. 506.

1883.

Petri . . .	Zum Verhalten der Aldehyde, des Traubenzuckers, der Peptone, der Eiweisskörper und des Acetons gegen Diazobenzolsulfonsäure. (March 10.)	'Zeitschr. physiol. Chem.' viii. 291–298; 'J. Chem. Soc.' xlvi. 1322–1323 (Abs.)
C. H. Wolff . .	Über die Dauer der spektralanalytischen Reaktion von Kohlenoxyd.	'Repert. anal. Chem.' iii. 82–84.
H. Quincke . .	Ueber das Verhalten des Harns nach Gebrauch von Copaivabalsam.	'Archiv. f. exp. Pathol. u. Pharmacol.' xvii. 273–277.

1884.

J. L. Soret . .	Sur la couleur de l'eau . . .	'J. de Phys.' [2] iii. 427–442.
A. Jäderholm . .	Studien über Methämoglobin . .	'Zeitschr. f. Biol.' xx. 419–448; 'J. Chem. Soc.' xlviii. 407 (Abs.); 'Ber.' xviii. Referate, 480–481 (Abs.)
Wl. Tichomirow .	Zur spectroscopische Eigenschaften der Canthariden und ihrer Präparate.	'Pharm. Zeitschr. fur Russland,' 1884, 637–642 and 649–659; 'Ber.' xvii. Referate, 541 (Abs.)
J. H. Stebbins, jun.	On the Spectroscopic Investigation of Lauth's violet and Methylene Blue. (Read Dec. 5.)	'Proc. Am. Chem. Soc.' vi. 304–305; 'Ber.' xviii. Referate, 159 (Abs.)
W. N. Hartley .	The Absorption-spectra of the Alkaloids. (Recd. Nov. 19. Read Dec. 11.)	'Phil. Trans.' clxxvi. 471–521; 'Proc. Roy. Soc.' xxxviii. 1–4 (Abs.); 'J. Chem. Soc.' xlviii. 1174 (Abs.)

ABSORPTION SPECTRA, 1884, 1885.

R. Wegscheider .	Spectroscopische Notizen über die Farbstoffe grünes Blätter und ihres Derivate.	'Ber. Deutsch Bot. Gesellsch.' ii. 494–502; 'Beiblätter,' ix. 260 (Abs.)

1885.

W. de W. Abney and R. Festing.	Absorption-spectra Thermograms. (Recd. Dec. 31, 1884. Read Jan. 15, 1885.)	'Proc. Roy. Soc.' xxxviii. 77–83; 'J. Chem. Soc.' xlviii. 1175–1176 (Abs.)
C. A. MacMunn .	Observations on the Chromatology of Actiniæ. (Recd. Jan. 8. Read Jan. 22.)	'Phil. Trans.' clxxvi. 641–663; 'Proc. Roy. Soc.' xxxviii. 85–87 (Abs.); 'J. Chem. Soc.' xlviii. 1251 (Abs.)
C. Kubierschky .	Ueber die Thiophosphorsäuren .	'J. pr. Chem.' xxxi. 93–111.
P. T. Cleve . .	Contributions to the knowledge of Samarium. (Read Feb. 13.)	'Nova Acta R. Soc. Sci. Upsala' [3] xiii. 39 pp.; 'Chem. News,' liii. 30–31, 45–47, 67–69, 80–82, 91–93, 100–102.
C. A. MacMunn .	Observations on some of the colouring matters of Bile and Urine, with especial reference to their origin; and on an easy method of procuring Haematin. (Read Feb. 14.)	'Proc. Physiol. Soc.' 1885, No. I. i.–iv.
E. Guignet . .	Extraction de la matière verte des feuilles; combinaisons définies formées par la chlorophyll. (Read Feb. 16.)	'C. R.' c. 434–437; 'Ber.' xviii. Referate, 196–197 (Abs.)
W. N. Hartley .	The Absorption Spectra of the Alkaloids. Part II. (Recd. March 5. Read March 12.)	'Phil. Trans.' clxxvi. 471–521; 'Proc. Roy. Soc.' xxxviii. 191–193 (Abs.); 'Chem. News,' l. 287 (Abs.); 'Beiblätter,' ix. 259–260 (Abs.); 'J. Chem. Soc.' xlviii. 1174 (Abs.)
C. A. Schunk . .	Quantitative Investigation of the Absorption Spectrum of the Blue Potassium Chromium Oxalate. (University College Chemical and Physical Society. Read March 19.)	'Chem. News,' li. 152–153 (Abs.)
H. Deslandres .	Relations entre le spectre ultraviolet de la vapeur d'eau et les bandes telluriques A, B, α du spectre solaire. (Read March 23.)	'C. R.' c. 854–857; 'Ber.' xviii. Referate, 253 (Abs.); 'J. Chem. Soc.' xlviii. 713–714 (Abs.); 'Beiblätter,' ix. 630–631 (Abs.)
L. Bell . . .	Notes on the Absorption Spectrum of Nitrogen Peroxide.	'Am. Chem. J.' vii. 32–34; 'Ber.' xviii. Referate, 400 (Abs.); 'J. Chem. Soc.' xlviii. 949 (Abs.); 'Beiblätter,' ix. 578-579 (Abs.)
T. Lehmann and J. Petri.	Zur Kenntniss des Liebermann'schen Phenolfarbstoffs.	'Arch. der Pharm.' [3] xxiii. 243–248; 'Ber.' xviii. Referate, 625–626 (Abs.)

ABSORPTION SPECTRA, 1885.

C. A. MacMunn .	Observations on some of the Colouring Matters of Bile and Urine, with especial reference to their origin; and on an easy method of procuring Haematin from Blood.	'J. of Physiol.' vi. 22–39; 'J. Chem. Soc.' l. 638 (Abs.)
W. N. Hartley .	On Chlorophyll from the Deep Sea. (Read April 6.)	'Proc. Roy. Soc. Edinb.' xiii. 130–136; 'J. Chem. Soc.' l. 367 (Abs.)
E. B. Poulton .	The Essential Nature of the Colouring of Phytophagous Larvæ (and their Pupæ); with an Account of some Experiments upon the Relation between the Colour of such Larvæ and that of their Food-plants. (Recd. April 11. Read April 23.)	'Proc. Roy. Soc.' xxxviii. 269–315; 'Nature,' xxxii. 91–93 (Abs.)
C. A. MacMunn .	Further Observations on Enterochlorophyll and Allied Pigments. (Recd. April 21. Read April 30.)	'Phil. Trans.' clxxvii. 235–266; 'Proc. Roy. Soc.' xxxviii. 319–322 (Abs.); 'Nature,' xxxii. 69 (Abs.); 'J. Chem. Soc.' xlviii. 1242 (Abs.)
J. G. Otto . .	Untersuchungen über die Blutkörperchenzahl und den Hämoglobingehalt des Blutes.	'Pflüger's Arch. f. Physiol.' xxxvi. 12–72; 'Ber.' xix. Referate, 146–149 (Abs.)
E. Schunck . .	Contributions to the Chemistry of Chlorophyll. (Recd. April 30. Read May 7.)	'Proc. Roy. Soc.' xxxviii. 336–340 (Abs.); 'Nature,' xxxii. 117–118 (Abs.); 'Ber.' xviii. Referate, 567 (Abs.); 'J. Chem. Soc.' xlviii. 1241–1242 (Abs.)
W. N. Hartley .	Researches on the Relation between the Molecular Structure of Carbon Compounds and their Absorption Spectra. Part VII. (Read May 7.)	'J. Chem. Soc.' xlvii. 685–757; 'Nature,' xxxii. 93–94 (Abs.); 'Chem. News,' li. 235 (Abs.); 'Ber.' xviii. Referate, 592–593 (Abs.); 'Am. J.' [3] xxxi. 58–59 (Abs.); 'Beiblätter,' x. 402–404 (Abs.)
E. Linnemann .	Verarbeitung und qualitative Zusammensetzung des Zirkons. (Read May 7.)	'Sitzungsb. Wien. Akad.' xci. II. 1019–1031; 'Monatshefte,' vi. 335–347; 'Chem. News,' lii. 233–235, 240–242.
G. Krüss . .	Beziehungen zwischen der Zusammensetzung und den Absorptionsspectren organischer Verbindungen. II. (Recd. May 20)	'Ber.' xviii. 1426–1433; 'J. Chem. Soc.' xlviii. 949 (Abs.); 'Beiblätter,' ix. 632–633 (Abs.)
J. S Konic . .	Ueber das Absorption-spectrum des Benzoldampfes. (From a Polish paper.)	'Beiblätter,' ix. 669–670 (Abs.)
W. J. Russell .	Spectroscopic Observations on Dissolved Cobaltous Chloride. (Chem. Soc. May 21.)	Chem. News,' li. 259–260; 'Beiblätter,' x. 570–571 (Abs.)
C. F. W. Krukenberg	Die farbigen Derivate der Nebennierenchromogene. (June 3.)	'Archiv. f. path. Anat.' ci. 542–571; 'Ber.' xix. Referate, 500–502 (Abs.)

ABSORPTION SPECTRA, 1885.

G. Krüss	Titerstellung der Lösungen von Kaliumpermanganat. (Recd. June 10.)	'Ber.' xviii. 1580–1585; 'Beiblätter,' ix. 740 (Abs.)
C. Auer v. Welsbach.	Die Zerlegung des Didyms in seine Elemente. (Read June 18.)	'Sitzungsb. Wien. Akad.' xcii. II. 317–331; 'Monatshefte,' vi. 477–491; 'Wien. Anz.' 1885, 137–138 (Abs.); 'Chem. News,' lii. 49 (Abs.); 'J. Chem. Soc.' xlviii. 1113 (Abs.); 'Ber.' xviii. Referate, 605 (Abs.); 'Beiblätter,' ix. 645–646 (Abs.)
A. Pabst	Sur le jus de framboise	'Bull. Soc. Chim.' xliii. 363–366; 'J. Chem. Soc.' l. 387–388 (Abs.)
E. Linnemann	Über die Absorptionserscheinungen in Zirkonen. (Read July 9.)	'Sitzungsb. Wien. Akad.' xcii. II. 427–432; 'Monatsh. f. Chem.' vi. 531–536; 'Ber.' xviii. Referate, 605 (Abs.); 'J. Chem. Soc.' xlviii. 1173–1174 (Abs.); 'Chem. News,' lii. 220–221.
J. Janssen	Spectres telluriques. (Read July 13.)	'C. R.' ci. 111–112.
C. Girard and Pabst	Sur les spectres d'absorption de quelques matières colorantes. (Read July 13.)	'C. R.' ci. 157–160; 'Chem. News,' lii. 54–55 (Abs.); 'J. Chem. Soc.' xlviii. 1098 (Abs.); 'J. de Pharm.' [5] xii. 306–309.
S. v. Kostanecki and S. Niementowski.	Ueber die isomeren Dioxydimethylanthrachinone. (Recd. Aug. 5.)	'Ber.' xviii. 2138–2141.
M. Nencki	Ueber das Parahämoglobin. (Aug. 1885.)	'Archiv f. exp. Pathol.' xx. 332–346; 'Ber.' xix. Referate, 605–606 (Abs.)
N. Egoroff	Absorption spectrum of Air. (Read Sept. 24. In Russian.)	'J. soc. phys.-chim. russe,' xvii. 229 (Abs.)
H. W. Vogel	Ueber den Zusammenhang zwischen Absorption der Farbstoffe und deren sensibilisirenden Wirkung auf Bromsilber. (Sept. 1885.)	'Ann. Phys. u. Chem.' N.F. xxvi. 527–530; 'J. Chem. Soc.' l. 585 (Abs.)
C. A. MacMunn	On the Chromatology of the Blood of some Invertebrates.	'Quarterly J. Micros. Sci.' 1885, 469–490.
J. Janssen	Analyse spectrale des éléments de l'atmosphère terrestre. (Read Oct. 5.)	'C. R.' ci. 649–651; 'Nature,' xxxii. 591 (Abs.); xxxiii. 89 (Abs.); 'Chem. News,' lii. 213 (Abs.); 'Ber.' xviii. Referate, 672 (Abs.); 'J. Chem. Soc.' l. 1 (Abs.); 'Beiblätter,' ix. 789 (Abs.)
E. L. Nichols	A Spectro-photometric Analysis of the Colour of the Sky.	'Proc. Amer. Assoc.' 1885, 78, 79.

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W. D. Halliburton .	On the Blood of Decapod Crustacea.	'J. of Physiol.' vi. 300–335; 'J. Chem. Soc.' l. 639–640 (Abs.)
D. Axenfeld .	Die Wirkung der Halogene auf das Hæmin. (Nov. 21.)	'Centralbl. f. d. med. Wissensch.' 1885, 833–835; 'Ber.' xix. Referate, 578 (Abs.)
C. A. MacMunn .	Researches on Myohæmatin and the Histohæmatins. (Recd. Oct. 19. Read Nov. 26.)	'Phil. Trans.' clxxvii. 267–298; 'Proc. Roy. Soc.' xxxix. 248–252 (Abs.); 'J. Chem. Soc.' l. 568 (Abs.); 'Ber.' xx. Referate, 333–334 (Abs.)
J. M. Eder . .	Über die Wirkung verschiedener Farbstoffe auf das Verhalten des Bromsilbers gegen das Sonnenspectrum und spectroskopische Messungen über den Zusammenhang der Absorption und photographischer Sensibilisirung. (Read Dec. 3.)	'Sitzungsb. Wien. Akad.' xcii. II. 1346–1372; 'Monatshefte,' vi. 927–953; 'Wien. Anz.' 1885, 242–243 (Abs.); 'Ber.' xix. Referate, 132 (Abs.); 'J. Chem. Soc.' l. 405–406 (Abs.); 'Beiblätter,' x. 228–230 (Abs.)
C. Ochsenius . .	Blaues Steinsalz aus dem Egeln-Stassfurter Kalisalzlager. (Dec. 7.)	'N. Jahrb. f. Min.' 1886, i. 177; 'J. Chem. Soc.' l. 515 (Abs.)
N. Egoroff . .	Spectre d'absorption de l'oxygène. (Read Dec. 7.)	'C. R.' ci. 1143–1145; 'Nature,' xxxiii. 168 (Abs.); 'Ber.' xix. Referate, 6 (Abs.); 'J. Chem. Soc.' l. 189 (Abs.); 'Beiblätter,' x. 357 (Abs.)
J. M. Eder . .	Photometrische Versuche über die sensibilisirende Wirkung von Farbstoffen auf Chlorsilber und Bromsilber bei verschiedenen Lichtquellen und Notizen zur orthochromatischen Photographie. (Read Dec. 17.)	'Sitzungsb. Wien. Akad.' xciii. 4–11; 'Monatsh. f. Chem.' vii. 1–8; 'Ber.' xix. Referate, 235–236 (Abs.); 'J. Chem. Soc.' l. 497 (Abs.)
R. Kayser . .	Ueber das Lokao oder chinesische Grün. (Recd. Dec. 27.)	'Ber.' xviii. 3417–3429.
Doumer u. Thibaut	Spectral-analyse der Oele . .	'Chem. Zeitung,' ix. 534; 'Chem. News,' li. 229 (Abs.)

1886.

H. Becquerel . .	Sur les variations des spectres d'absorption et des spectres d'émission par phosphorescence d'un même corps. (Read Jan. 11.)	'C. R.' cii. 106–110; 'Chem. News,' liii. 77–78; 'Beiblätter,' x. 500–501 (Abs.)
W. Crookes . .	On Radiant Matter Spectroscopy; Note on the Spectra of Erbia. (Recd. Jan. 7. Read Jan. 21.)	'Proc. Roy. Soc.' xl. 77–79; 'Nature,' xxxiii. 474; 'Chem. News,' liii. 75–76; 'J. Chem. Soc.' l. 749 (Abs.)
M. Nencki and N. Sieber.	Venöse Hämoglobinkrystalle. (Read Jan. 27.)	'Ber.' xix. 128–130; 'J. Chem. Soc.' l. 374 (Abs.)
" .	Berichtigung. (Read Feb 22.)	'Ber.' xix. 410.

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C. Liebermann .	Ueber Azoopiansäure und einen neuen Indigoabkömmling. (Read Feb. 8.)	'Ber.' xix. 351–354.
C. A. MacMunn .	Haematoporphyrin. (Read Feb. 13.)	'Proc. Physiol. Soc.' 1886, 1–2; 'J. Chem. Soc.' l. 638 (Abs.)
W. D. Halliburton .	Haemoglobin and Methaemoglobin Crystals of Rodents. (Read Feb. 13.)	'Proc. Physiol. Soc.' 1886, 2–4; 'J. Chem. Soc.' l. 637 (Abs.)
L. Macchiati . .	La Xantofillidrina. (Feb. 15.)	'Gazz. chim. ital.' xvi. 231–234; 'Ber.' xix. Referate, 887 (Abs.)
A. Recoura . .	Sur les états isomériques du sesquichlorure de chrome, sesquichlorure vert. (Read March 1.)	'C. R.' cii. 515–518; 'Ber.' xix. Referate, 233 (Abs.) 'J. Chem. Soc.' l. 508–510 (Abs.)
J. Reinke . .	Photometrische Untersuchungen über die Absorption des Lichtes in dem Assimilations-organem.	'Bot. Zeitung,' 1886, 161–171 and 241–248; 'Beiblätter,' xi. 709–710 (Abs.)
A. Recoura . .	Sur les états isomériques du sesquichlorure de chrome. Chlorure hydraté gris. Chlorure anhydre. (Read March 8.)	'C. R.' cii. 548–551; 'Ber. xix. Referate, 233 (Abs.); 'J. Chem. Soc.' l. 508–510 (Abs.)
Lecoq de Boisbaudran.	Sur la mosandrine de Laurence Smith. (Read March 15.)	'C. R.' cii. 647–648; 'Chem. News,' liii. 168 (Abs.); 'Ber.' xix. Referate, 234–235 (Abs.); 'J. Chem. Soc.' l. 507 (Abs.)
W. Schjerning .	Ueber die Absorption der ultra-violetten Lichtstrahlen durch verschiedene optische Gläser. (Inaug, Diss. 1886.)	'Beiblätter,' xi. 340–341 (Abs.)
C. Timiriazeff .	La chlorophylle et la réduction de l'acide carbonique par les végétaux. (Read March 22.)	'C. R.' cii. 686–689; 'Chem. News,' liii. 180 (Abs.); 'Ber.' xix. Referate, 355 (Abs.)
T. S. Humpidge .	The Spectra of Erbia. (March 22.)	'Chem. News,' liii. 154–155.
E. Noah . . .	Pentaoxyanthrachinon und Anthrachryson. (Read March 22.)	'Ber.' xix. 751–755.
E. L. Kahn . .	Ueber Dimethylanthrachryson. (Read March 22.)	'Ber.' xix. 755–757; 'J. Chem. Soc.' l. 556 (Abs.)
H. W. Vogel . .	Ueber einige Farbenwahrnehmungen und über Photographie in natürlichen Farben. (March, 1886.)	'Ann. Phys. u. Chem.' N.F. xxviii. 130–135; 'J. Chem. Soc.' l. 749–750 (Abs.); 'Nature,' xxxiv. 254 (Abs.)
W. N. Hartley .	The Spectra of Erbia . . .	'Chem. News,' liii. 179.

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Lecoq de Boisbaudran.	L'holmine (ou terre X de M. Soret) contient au moins deux radicaux métalliques. (Read May 3.)	'C. R.' cii. 1003–1004; 'Chem. News,' liii. 265; 'Ber.' xix. Referate, 388 (Abs.); 'J. Chem. Soc.' l. 667 (Abs.); 'Am. J.' [3] xxxii. 406 (Abs.)
,,	Sur le dysprosium. (Read May 3).	'C. R.' cii. 1005–1006; 'Chem. News,' liii. 265–266; 'Ber.' xix. Referate, 388 (Abs.); 'J. Chem. Soc.' l. 667 (Abs.); 'Am. J.' [3] xxxii. 406 (Abs.)
H. Gorceix . .	Sur la 'xénotime' de Minas Geraes. (Brésil.) (Read May 3.)	'C. R.' cii. 1024–1026; 'J. Chem. Soc.' l. 676 (Abs.)
E. van Aubel . .	Note sur la transparence du platine. (Read May 11.)	'Bull Acad. Roy. Belg.' [3] xi. 408–414; 'Nature,' xxxiv. 330 (Abs.)
C. Timiriazeff. .	Chlorophyll	'Nature,' xxxiv. 52.
J. M. Eder . .	Über die Wirkung verschiedener Farbstoffe auf das Verhalten des Bromsilbers gegen das Sonnenspectrum. (Read June 10.)	'Sitzungsb. Wien. Akad.' xciv. II. 75–94; 'Monatsh. f. Chem.' vii. 331–350; 'J. Chem. Soc.' l. 958–959 (Abs.); 'Beiblätter,' v. 701–702 (Abs.)
S. Rideal . .	Note on the Blue Colouring-matter of Decaying Wood.	'Chem. News,' liii. 277–278; 'J. Chem. Soc.' l. 810 (Abs.)
J. Janssen . .	Sur les spectres d'absorption de l'oxygène. (Read June 15.)	'C. R.' cii. 1352–1353; 'Nature,' xxxiv. 176 (Abs.); 'Chem. News,' liv. 19 (Abs.); 'Ber.' xix. Referate, 479 (Abs.); 'J. Chem. Soc.' l. 749 (Abs.)
E. Demarçay . .	Sur les spectres du didyme et du samarium. (Read June 28.)	'C. R.' cii. 1551–1552; 'Chem. News,' liv. 36–37 (Abs.); 'J. Chem. Soc.' l. 837–838 (Abs.); 'Ber.' xix. Referate, 650–651 (Abs.); 'Beiblätter,' x. 622–623 (Abs.)
P. Sabatier . .	Spectres d'absorption des chromates alcalins et de l'acide chromique. (Read July 5.)	'C. R.' ciii. 49–52; 'Chem. News,' liv. 44; 'J. Chem. Soc.' l. 838–839 (Abs.); 'Ber.' xix. Referate, 649 (Abs.); 'Beiblätter,' xi. 223 (Abs.)
J. M. Eder . .	Über einige geeignete praktische Methoden zur Photographie des Spectrums in seinen verschiedenen Bezirken mit sensibilisirten Bromsilberplatten. (Read July 8.)	'Sitzungsb. Wien. Akad.' xciv. II. 378–403; 'Monatsh. f. Chem.' vii. 429–454; 'Ber.' xix. Referate, 743 (Abs.); 'Beiblätter,' xi. 39–40 (Abs.); 'J. Chem. Soc.' lii. 93 (Abs.)
W. Crookes . .	Note on the Absorption Spectrum of Didymium.	'Chem. News,' liv. 27; 'Nature,' xxxiv. 266; 'Ber.' xix. Referate, 652 (Abs.)

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H. Becquerel . .	Sur les variations des spectres d'absorption dans les milieux non isotropes. (Read July 19.)	'C. R.' ciii. 198–202; 'Nature,' xxxiv. 307 (Abs.); 'Beiblätter,' xi. 347 (Abs.)
E. L. Cahn . .	Ueber Methylanthragallole. (Recd. Aug. 2.)	'Ber.' xix. 2333–2336; 'J. Chem. Soc.' lii. 57 (Abs.)
E. Noah . . .	Ueber zwei neue Tetraoxyanthrachinone. (Recd. Aug. 2.)	'Ber.' xix. 2337–2340.
C. Liebermann and S. Kleemann.	Ueber Opiansäurederivate. (Recd. Aug. 11.)	'Ber.' xix. 2287–2299.
C. Liebermann and St. v. Kostanecki.	Ueber die Spektra der methylirten Oxyanthrachinone. (Recd. Aug. 13.)	'Ber.' xix. 2327–2332.
W. D. Halliburton .	Note on the Colouring Matter of the Serum of certain Birds.	'J. of Physiol.' vii. 324–326; 'J. Chem. Soc.' l. 1050 (Abs.)
W. J. Russell and W. Lapraik.	Absorption Spectra of Uranium Salts. (Brit. Assoc.)	'Nature,' xxxiv. 510 (Abs.); 'Beiblätter,' xi. 822 (Abs.)
G. Hoppe-Seyler .	Zur Unterscheidung der Chrysophansaüre von dem Santonin-farbstoff im Harn. (Berlin Med. Wochenschrift, xxiii. 436–437.)	'Chem. Centr.' 1886, 746 (Abs.); 'J. Chem. Soc.' lii. 406 (Abs.)
J. Belky . . .	Beiträge zur Kenntniss der Wirkung der gasförmigen Gifte.	'Archiv. f. Anat. u. Physiol.' cvi. 148–165; 'Chem. Centr.' 1886, 887–889 (Abs.); 'J. Chem. Soc.' lii. 392 (Abs.)
G. Krüss . . .	Ueber die Oxyde des Goldes. (Read Oct. 11.)	'Ber.' xix. 2541–2549; 'J. Chem. Soc.' lii. 15–16 (Abs.)
Hénocque . .	L'hématoscopie, méthode nouvelle d'analyse du sang, basée sur l'emploi du spectroscope. (Read Nov. 2.)	'C. R.' ciii. 817–820; 'Nature,' xxxv. 48 (Abs.); 'Ber.' xx. Referate, 25 (Abs.); 'J. Chem. Soc.' lii. 312 (Abs.); 'Zeitschr. f. Instrumentenkunde,' vii. 220–221 (Abs.)
S. P. Langley, C. A. Young, and E. C. Pickering.	Pritchard's Wedge Photometer. (Nov. 10.)	'Ann. Harvard Coll. Obs.' xviii. 301–324; 'Nature,' xxxvi. 477–478 (Abs.); 'Am. J.' [3] xxxiv. 401 (Abs.)
W. N. Hartley .	Spectroscopic Notes on the Carbohydrates and Albuminoids from Grain. (Read Nov. 18.)	'J. Chem. Soc.' li. 58–61; 'Chem. News,' liv. 270 (Abs.); 'Beiblätter,' xi. 437–438 (Abs.)
" .	Researches on the Relation between the Molecular Structure of Carbon Compounds and their Absorption Spectra. Part VIII. A Study of Coloured Substances and Dyes. (Read Nov. 18.)	'J. Chem. Soc.' li. 152–202; 'Chem. News,' liv. 269–270 (Abs.); 'Ber.' xx. Referate, 131–132 (Abs.), 'Beiblätter,' xi. 537–538 (Abs.)
Grimbert . .	Sur une épidémie de micrococcus prodigiosus (Erenberg).	'J. de Pharm.' [5] xiv. 547–549; 'Chem. News,' lv. 69 (Abs.)

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E. Schunck . .	Contributions to the Chemistry of Chlorophyll. No. II. (Recd. Nov. 25. Read Dec. 16.)	'Proc. Roy. Soc.' xlii. 184–188; xli. 465–466 (Abs.); 'Ber.' xx. Referate, 724–726 (Abs.); 'J. Chem. Soc.' lii. 972 (Abs.)
A. Ewald . .	Polari-spectroskopische Untersuchungen an Blutkrystallen.	'Zeitschr. f. Biol.' xxii. 459–479; 'Ber.' xx. Referate, 112 (Abs.)
C Krukenberg .	Ueber das Spectralverhalten einiger physiologisch und klinisch interessanten Farbenreactionen. (Chem. Untersuch. zur wissenschft. Medicin, Jena 1886, 74.)	'Zeitschr. f. anal. Chem.' xxvi. 672 (Abs.); 'Chem. News,' lvii. 231 (Abs.)
E. Hering . .	Spectroskopische Methode zum Nachweis des Blutfarbstoffs. (Prager medic. Wochenschrift, 1886, 97.)	'Zeitschr. f. anal. Chem.' xxvi. 124 (Abs.); 'Chem. News,' lvi. 105 (Abs.)

1887.

Hoppe-Seyler . .	Caractères distinctifs des colorations de l'urine par l'acide chrysophanique et la santonine.	'J. de Pharm.' xv. 35; 'Chem. News,' lv. 70 (Abs.)
A. W. Hofmann .	Ueber das Chinolinroth. (Read Jan. 10.)	'Ber.' xx. 4–20.
H. Becquerel .	Sur les lois de l'absorption de la lumière dans les cristaux et sur une méthode nouvelle permettant de distinguer dans un cristal certaines bandes d'absorption appartenant à des corps différents. (Read Jan. 17.)	'C. R.' civ. 165–169; 'Chem. News,' lv. 93 (Abs.); 'Beiblätter,' xi. 347 (Abs.)
K. Olszewski . .	Über das Absorptions-Spectrum des flüssigen Sauerstoffes und der verflüssigten Luft. (Read Jan. 20.)	'Sitzungsb. Wien. Akad.' xcv. II. 257–261; 'Monatsh. f. Chemie,' viii. 73–77; 'Nature,' xxxvi. 42 (Abs.); 'Ber.' xx. Referate, 245–246 (Abs.); 'J. Chem. Soc.' lii. 625 (Abs.); 'Am. J.' [3] xxxiv. 63–64 (Abs.); 'Chem. News,' lv. 45 (Abs.)
F. Krüger . .	Beobachtungen über die Absorption des Lichtes durch das Oxyhämoglobin.	'Zeitschr. f. Biol.' xxiv. 47–66; 'J. Chem. Soc.' lii. 1126–1127 (Abs.); 'Ber.' xxi. Referate, 64 (Abs.)
E. B. Poulton . .	An Inquiry into the Cause and Extent of a special Colour Relation between certain exposed Lepidopterous Pupæ and the Surfaces which immediately surround them. (Recd. Feb. 10. Read Feb. 10.)	'Proc. Roy. Soc.' xlii. 94–108 (Abs.)
N. Kowalewsky .	Über die Bildung von Methämoglobin im Blut unter Einwirkung von Alloxantin. (Med. C.-Bl. xxv. 1–3, 17–18.)	Chem. Centr.' 1887, 164 (Abs.); 'J. Chem. Soc.' lii. 508 (Abs.)

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C. Liebermann and W. Wense.	Zur Kenntniss der färbenden Oxyanthrachinone. (Read Feb. 28.)	'Ber.' xx. 862–866.
E. Demarçay . .	Sur les terres de la cérite. (Read Feb. 28.)	'C. R.' civ. 580.
E. H. Rennie . .	The Colouring Matter of Drosera Whittakeri. Preliminary Notice. (Read March 3.)	'J. Chem. Soc.' li. 371–377.
C. A. MacMunn .	Chromatology of Sponges. (Read March 12.)	'Proc. Physiol. Soc.' 1887, 11–12; 'J. Chem. Soc.' lii. 613 (Abs.)
H. Becquerel . .	Sur les variations des spectres d'absorption du didyme. (Read March 14.)	'C. R.' civ. 777–780; 'Nature,' xxxv. 503–504 (Abs.); 'Chem. News,' lv. 148–149; 'Ber.' xx. Referate, 246 (Abs.); 'J. Chem. Soc.' lii. 537–538 (Abs.); 'Beiblätter,' xi. 538–539 (Abs.)
A. Bernthsen and A. Goske.	Ueber Monomethyl- und Monoäthylorange und ihre Ueberführung in Dimethyl- und Diäthylthionin. (Recd. March 24. Read March 28.)	'Ber.' xx. 924–934; 'J. Chem. Soc.' lii. 666–667 (Abs.)
L. Levy . . .	Ueber Farbstoffe in den Muskeln .	'Zeitschr. physiol. Chemie,' xiii. 309–325; 'J. Chem. Soc.' lvi. 633 (Abs.)
R. E. Schmidt .	Ueber den Farbstoff des Lac-dye. (Jan. 1887. Read April 25.)	'Ber.' xx. 1285–1303.
G. Krüss and L. F. Nilson.	Studien über die Componenten der Absorptionsspectra erzeugenden seltenen Erden. (Read April 25.)	'Ber.' xx. 2134–2171; 'Nature,' xxxvi. 324 (Abs.); 'J. Chem. Soc.' lii. 890–892 (Abs.); 'Beiblätter,' xi. 707–708 (Abs.); 'Chem. News,' lvi. 74–77, 85–87, 135–137, 145–147, 154–156, 165–167, 172–173.
C. le Nobel . .	Ueber die Einwirkung von Reductions-mitteln auf Hæmatin und das Vorkommen der Reductionsproducte in pathologischem Harne.	'Pflüger's Archiv,' xl. 501–523; 'Chem. Centr.' 1887, 538 (Abs.); 'J. Chem. Soc.' lii. 1127 (Abs.)
A. Hénocque . .	Note sur l'étude hématoscopique du sang dans l'intoxication par l'oxyde de carbone. (Read May 7.)	'C. R. Soc. de Biol.' [8] iv. 283–286.
G. Linossier .	Sur une combinaison de l'hématine avec le bioxyde d'azote. (Read May 9.)	'C. R.' civ. 1296–1298; 'Chem. News,' lv. 272–273 (Abs.); 'J. Chem. Soc.' lii. 854-855 (Abs.)
L. Lewin and C. Posner.	Zur Kenntniss der Haematurie.	'Centralbl. f. d. med. Wissensch.' 1887, 354–356; 'Ber.' xx. Referate, 801 (Abs.)
C. M. Thompson .	Note on the Spectrum of Didymium .	'Chem. News,' lv 227; 'Nature,' xxxvi. 115; 'Beiblätter,' xii. 195 (Abs.)

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G. Linossier .	Sur une combinaison de l'hématine avec le bioxyde d'azote.	'Bull. Soc. Chim.' xlvii. 758–760; 'Ber.' xx. Referate, 793–794 (Abs.); xxi. Referate, 63-64 (Abs.)
C. A. MacMunn .	Further Observations on Myohæmatin and the Histohæmatins.	'J. of Physiol.' viii. 51-65; 'J. Chem. Soc.' lii. 983 (Abs.)
H. Becquerel .	Sur les variations des spectres d'absorption des composés du didyme. (Read June 13.)	'C. R.' civ. 1691–1693; 'Chem. News,' lvi. 23 (Abs.); 'Ber.' xx. Referate, 457 (Abs.); 'J. Chem. Soc.' lii. 873 (Abs.); 'Beiblätter,' xii. 49 (Abs.)
W. N. Hartley .	On the Absorption-Spectrum of a Base from Urine. (Appendix to a paper On the Kreatinin of Urine as distinguished from that obtained from Flesh Kreatin. II. On the Kreatinins derived from the Dehydration of Urinary Kreatin by G. S. Johnson.) (Recd. May 5. Read June 16.)	'Proc. Roy. Soc.' xliii. 529–534; 'J. Chem. Soc.' lvi. 165–166 (Abs.)
C. H. Bothamley .	Ortho-chromatic Photography .	'J. Soc. Chem. Ind.' vi. 423-433; 'J. Chem. Soc.' lii. 874–877 (Abs.)
E. Prost . . .	Sur le sulfure de cadmium colloïdal. (June 1887.)	'Bull. Acad. Belg.' [3] xiv. 312-321; 'Nature,' xxxvii. 23 (Abs.)
P. Sabatier . .	Spectres d'absorption des chromates alkalins et de l'acide chromique.	'Ann. de la Fac. des Sciences de Toulouse,' i. D_1 to D_{11}; 'J. de Phys. [2] vi. 312–320.
E. Demarçay . .	Sur les spectres du didyme et du samarium. (Read Aug. 1.)	'C. R.' cv. 276–277; 'Chem. News,' lvi. 114 (Abs.); 'Ber.' xx. Referate, 533 (Abs.); 'J. Chem. Soc.' lii. 1008 (Abs.); 'Beiblätter,' xi. 708 (Abs.)
A. E. Tutton . .	The Chemistry of the Rare Earths .	'Nature,' xxxvi. 357–358.
A. Michaelis . .	Zur Kenntniss der Chloride des Tellurs. (Recd. Aug. 13.)	'Ber.' xx. 2488–2492; 'Beiblätter, xi. 778 (Abs.)
G. H. Bailey . .	The Absorption Spectra of the Haloid Salts of Didymium. (Brit. Assoc.)	'Nature,' xxxvi. 570 (Abs.)
,, . .	The Absorption Spectra of Rare Earths. (Brit. Assoc.)	'Nature,' xxxvi. 570 (Abs.)
,, . .	Die Componenten der Absorptionsspectra erzeugenden seltenen Erden. (Recd. Oct. 8.)	'Ber.' xx. 2769–2770; 'J. Chem. Soc.' liv. 1 (Abs.)
G. Krüss and L. F. Nilson.	Die Componenten der Absorptionsspectra erzeugenden seltenen Erden. (Recd. Nov. 12. Read Nov. 14.	'Ber.' xx. 3067–3072.

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C. Graebe . .	Ueber Auramin. (Recd. Dec. 1.)	'Ber.' xx. 3260–3268.
G. H. Bailey . .	Die Componenten der Absorptions-spectra erzeugenden seltenen Erden. (Recd. Dec. 14.)	'Ber.' xx. 3325–3327.
L. Lewin and C. Posner.	Zur Untersuchung des Harns auf Blutfarbstoff. (Centralbl. f. die medicin. Wissenschaften, 1887, 354.)	'Zeitschr. f. anal. Chem. xxvi. 672 (Abs.); 'Chem. News,' lvii. 231 (Abs.)
C. H. Wolff . .	Der spectroskopische Nachweis kleinster Blutmengen im Harn und anderen Flüssigkeiten. (Pharm. Centralhalle (N.F.), 8. Jahrg. 1887, 637.)	'Zeitschr. f. anal. Chem.' xxviii. 265–266; 'Chem. News,' lx. 50 (Abs.)
	1888.	
F. Stenger . .	Ueber die Gesetzmässigkeiten im Absorptionsspectrum eines Körpers. (Jan. 1888.)	'Ann. Phys. u. Chem.' N.F xxxiii. 577–586; 'J. Chem. Soc.' liv. 543 (Abs.); 'Ber.' xxi. Referate, 274 (Abs.)
G. Krüss and L. F. Nilson.	Die Componenten der Absorptions-spectren erzeugenden seltenen Erden. (Recd. Feb. 17.)	'Ber.' xxi. 585–588.
L. v. Udránsky .	Ueber Furfurolreactionen. (Recd. March 1.)	'Zeitschr. f. physiol. Chem.' xii. 355–376; 'J. Chem. Soc.' liv. 878–880 (Abs.)
G. H. Bailey . .	Die Componenten der Absorptions-spectren erzeugenden seltenen Erden. (Recd. March 15.)	'Ber.' xxi. 1520–1522.
J. Janssen .	Sur les spectres de l'oxygène. (Read April 16.)	'C. R.' cvi. 1118–1119; 'Nature,' xxxvii. 624 (Abs.); 'Chem. News,' lvii. 181 (Abs.); 'J. Chem. Soc.' liv. 765 (Abs.); 'Beiblätter,' xii. 527 (Abs.)
H. Bertin-Sans .	Sur le spectre de la méthémoglobine acide. (Read April 23.)	'C. R.' cvi. 1243–1245; 'J. Chem. Soc.' liv. 858–859 (Abs.); 'Ber.' xxi. Referate, 407 (Abs.); 'Beiblätter,' xii. 662 (Abs.)
G. Krüss . .	Beziehungen zwischen Zusammensetzung und Absorptionsspektrum organischer Verbindungen.	'Zeitschr. f. physikal. Chem.' ii. 312–337; 'J. Chem. Soc.' liv. 1141 (Abs.); 'Ber.' xxi. Referate, 393 (Abs.); 'Beiblätter,' xii. 789–790 (Abs.)
F. Krüger . .	Ueber die ungleiche Resistenz des Blutfarbstoffs verschiedener Thiere gegen zersetzende Agentien.	'Zeitschr. f. Biol.' xxiv. 318–335; 'J. Chem. Soc.' liv. 510–512 (Abs.)
H. W. Vogel . .	Ueber den Unterschied zwischen Heidelbeer- und Weinfarbstoff und über spectroskopische Weinprüfungen. (Recd. May 16.)	'Ber.' xxi. 1746–1753; 'J. Chem. Soc.' liv. 1137 (Abs.)

ABSORPTION SPECTRA, 1888.

W. N. Hartley	Researches on the Relation between the Molecular Structure of Carbon Compounds and their Absorption-Spectra. Part IX. On Isomeric Cresols, Dihydroxybenzenes, and Hydroxybenzoic Acid. (Read May 17.)	'J. Chem. Soc.' liii. 641–663; 'Beiblätter,' xii. 791 (Abs.)
"	Proof of the Identity of Natural and Artificial Salicylic Acid. (Read May 17.)	'J. Chem. Soc.' liii. 664.
H. Becquerel	Recherches sur les variations des spectres d'absorption dans les cristaux.	'Ann de Chim. et Phys.' [6] xiv. 170–257; 'Beiblätter,' xiii. 226-229 (Abs.)
"	Sur les variations des spectres d'absorption des composés du didyme.	'Ann Chim. et Phys.' [6] xiv. 257–279; 'Beiblätter,' xiii. 217–218 (Abs.)
H. W. Vogel	Beziehungen zwischen Zusammensetzung und Absorptionsspectrum organischer Farbstoffe. (June 1887.)	'Sitzungsb. Berlin. Akad.' 1887, 715–718; 'J. Chem. Soc.' liv. 97 (Abs.); 'Beiblätter,' xii. 48–49 (Abs.); 'Ber.' xxi. Referate, 776 (Abs.)
E. Schunck	Contributions to the Chemistry of Chlorophyll. No. III. (Recd. June 19. Read June 21.)	'Proc. Roy. Soc.' xliv. 448–454; xliv. 378 (Abs.); 'J. Chem. Soc.' lvi. 279–280 (Abs.); 'Ber.' xxii. Referate,' 268–270 (Abs.)
P. Kiesewetter and G. Krüss.	Beiträge zur Kenntniss der Absorptionsspectra erzeugenden seltenen Erden. (Recd. June 22. Read July 9.)	'Ber.' xxi. 2310–2320; 'Nature,' xxxviii. 326–327 (Abs.) 'J. Chem. Soc.' liv. 1038–1040 (Abs.); 'Beiblätter,' xiii. 19 (Abs.)
A. Schoeller	Ueber das Hystazarin. (Read July 23.)	'Ber.' xxi. 2503–2505; 'J. Chem. Soc.' liv. 1203–1204 (Abs.)
C. Liebermann	Ueber die Spectra der Aether der Oxyanthrachinone. (Recd. Aug. 1.)	'Ber.' xxi. 2527; 'J. Chem. Soc.' liv. 1203 (Abs.)
A. E. Tutton	The Absorption Spectra of Crystals	'Nature,' xxxviii. 343–344.
P. Kiesewetter and G. Krüss.	Contributions to a Knowledge of the Rare Earths which produce Absorption Spectra.	'Chem. News,' lviii. 75–76, 91–93.
G. D. Liveing and J. Dewar.	The Absorption-spectrum, Luminous and Ultra-violet, of large masses of Oxygen. (Aug. 18.)	'Phil. Mag.' [5] xxvi. 286–290; 'J. Chem. Soc.' lvi. 1 (Abs.); 'Ber.' xxi. Referate, 690 (Abs.); 'Beiblätter,' xiii. 16–17 (Abs.)
B. Walter	Ueber den Nachweis des Zerfalles von Moleculargruppen in Lösungen durch Fluorescenz- und Absorptionserscheinungen. (Sept. 1888.)	'Ann. Phys. u. Chem.' N.F. xxxvi. 518–532; 'J. Chem. Soc.' lvi. 554–555 (Abs.)
K. Katayama	Ueber eine neue Blutprobe bei der Kohlenoxydvergiftung.	'Archiv. f. path. Anat. u. Physiol.' cxiv. 53–54; Chem. Centr.' 1888, 1633 (Abs.); 'J. Chem. Soc.' lvi. 650–551 (Abs.)

ABSORPTION SPECTRA, 1888, 1889—PHYSICAL RELATIONS, 1883.

G. D. Liveing and J. Dewar.	On the Absorption Spectrum of Oxygen.	'Chem. News,' lviii. 163–164.
	Dr. Janssen on the Spectrum of Oxygen.	'Nature,' xxxviii. 605.
W. N. Hartley .	Ultra-violet Spectra of the Elements.	'Chem. News,' lviii. 304–305; 'Beiblätter,' xiii. 217 (Abs.)
L. Hermann . .	Notiz betr. das reducirte Hämoglobin.	'Pflüger's Archiv,' xliii. 235; 'Zeitschr. f. anal. Chem.' xxviii. 265 (Abs.); 'Chem News,' lx. 50 (Abs.); 'J. Chem Soc.' lvi. 530 (Abs.)
J. N. Lockyer .	Notes on Meteorites . . .	'Nature,' xxxviii. 424–428, 456–458, 530–533, 556–559, 602–605; xxxix. 139–142, 233–236, 400–402.

1889.

H. Becquerel . .	Sur les spectres d'absorption de l'épidote. (Read Feb. 11.)	'C. R.' cviii. 282–284; 'J. Chem. Soc.' lvi. 553 (Abs.)
E. Wertheimer and E. Meyer.	Sur l'apparition rapide de l'oxyhémoglobine dans la bile et sur quelques caractères spectroscopiques normaux de ce liquide. (Read Feb. 18.)	'C. R.' cviii. 357–359; 'J. Chem. Soc.' lvi. 636–637 (Abs.); 'Ber.' xxii. Referate, 273 (Abs.)
W. Crookes . .	Recent Researches on the Rare Earths as interpreted by the Spectroscope. (Presidential Address, Chemical Society, March 21.)	'J. Chem. Soc.' lv. 255–285; 'Nature,' xxxix. 537–543; 'Chem. News,' lx. 27–30, 39–41, 51–53, 63–66.
A. E. Bostwick .	Preliminary Note on the Absorption Spectra of Mixed Liquids.	'Am. J.' [3] xxxvii. 471–473; 'Nature,' xl. 189 (Abs.)
A. Letellier . .	Recherches sur la pourpre produite par le *Purpura lapillus*. (Read July 8.)	'C. R.' cix. 82–85; 'Chem. News,' lx. 49–50 (Abs.)
F. Hoppe Seyler .	Beiträge zur Kenntniss der Eigenschaften der Blutfarbstoffe.	'Zeitsch. für physiol. Chemie,' xiii. 477–496; 'J. Chem. Soc.' lvi. 787–788 (Abs.)

PHYSICAL RELATIONS.

1883.

S. P. Langley . .	Experimental Determination of Wave-lengths in the Invisible Prismatic Spectrum. (Read April 1883.)	'Mem. Nat. Acad. Sci.' ii. 149–162; 'Am. J.' [3] xxvii. 169–188; 'Phil. Mag.' [5] xvii. 194–214; 'J. de Phys.' [2] iii. 214–217 (Abs.); 'Ann. Chim. et Phys.' [6] ii. 145–176.
Donders . . .	Over de intensiteiten van mengsds van Spectraal-Kleuren, in betrekking tot die der componenten. (Read Oct. 27.)	'Proc. verb. Akad. Amsterdam,' 1883–84, No. 4, 5–6 (Abs.)

PHYSICAL RELATIONS, 1883, 1884.

Donders . . .	Over heterochrome intensiteitsvergelijkingen. (Read Oct. 27.)	'Proc. verb. Akad. Amsterdam,' 1883–84, No. 4, 6–7 (Abs.)
A. König . .	Ueber den neutralen Punkt im Spektrum der Farbenblinden. (Read Nov. 16.)	'Verhandl. phys. Ges. Berlin,' ii. 63–65; 'Nature,' xxix. 168 (Abs.)
Engelmann . .	Over een toestel tot kwantitatieve mikrospectraal - analyse (microspectraal - photometer). (Read Nov. 24.)	'Proc. verb. Akad. Amsterdam,' 1883–84, No. 5, 3–6 (Abs.)
F. Strohmer . .	Gehaltsbestimmung reiner wässeriger Glycerinlösungen mittelst ihrer Brechungsexponenten. (Read Dec. 20.)	'Monatshefte f. Chem.' v. 55–62; 'Beiblätter,' viii. 496 (Abs.)

1884.

G. Wyrouboff . .	Bestimmung der Brechungsexponenten des ammoniakalischen Seignettesalz.	'Bull. Soc. Min. de France,' vii. 8–10; 'Beiblätter,' viii. 512 (Abs.)
J. E. Keeler . .	On the Absorption of Radiant Heat by Carbon Dioxide. (April 1884.)	'Am. J.' [3] xxviii. 190–198; 'J. Chem. Soc.' xlviii. 626 (Abs.); 'Beiblätter,' ix. 258–259 (Abs.); 'J. de Phys.' [2] iv. 97–98 (Abs.)
R. Nasini . .	Sulle costanti di rifrazione. (Read June 15.)	'Atti R. Acc. Lincei Mem.' [3] xix. 195–218; 'Beiblätter' ix. 322–324 (Abs.)
A. Bartoli and E. Stracciati.	La proprietà fisiche degli idrocarburi C_nH_{2n+2} de petrolii di Pensilvania. (Read June 15.)	'R. Accad. Lincei, Transunti,' viii. 357 (Abs.); 'Gazz. chim. ital.' xv. 417–445; 'Il Nuovo Cimento,' xviii. 195–218; 'Ber.' xix. Referate, 249 (Abs.); 'Ann. Chim. et Phys.' [6] vii. 375–383 (Abs.)
E. L. Nichols . .	A Spectro-photometric Study of Pigments. (Amer. Assoc. Philadelphia.) (July 12.)	'Am. J.' [3] xxviii. 342–348; 'Beiblätter,' ix. 168–169 (Abs.)
W. Voigt . .	Ueber die Bestimmung der Brechungsindices absorbirender Medien.	'Göttinger Nachr.' 1884, 283–294.
K. Wesendonck .	Ueber die Diathermansie von Aesculinlösungen. (Aug. 7.)	'Ann. Phys. u. Chem.' N.F. xxiii. 548–553; 'J. Chem. Soc.' xlviii. 213 (Abs.)
T. Poleck . .	Ueber die chemische Constitution des Safrols. (Recd. Aug. 13.)	'Ber.' xvii. 1940–1944; 'Beiblätter,' ix. 31 (Abs.)
C. V. Zenger . .	Détermination des indices de réfraction par des mesures linéaires. (Read Aug. 25.)	'C. R.' xcix. 377–380; 'Beiblätter,' ix. 30–31 (Abs.)

PHYSICAL RELATIONS, 1884.

H. Becquerel	Détermination des longueurs d'onde des raies et bandes principales du spectre solaire infra-rouge. (Read Sept. 1.)	'C. R.' xcix. 417–420; 'Phil. Mag.' [5] xviii. 465–468; 'Chem. News,' l. 163 (Abs.); 'Am. J.' [3] xxviii. 391 (Abs.); xxviii. 457–459; 'Beiblätter,' viii. 818–819 (Abs.); 'Zeitschr. f. Instrumentenkunde,' v. 29–30 (Abs.)
Aubert and R. Dubois.	Sur les propriétés de la lumière des Pyrophores. (Read Sept. 15.)	'C. R.' xcix. 477–479; 'Nature,' xxx. 531 (Abs.); 'Beiblätter,' viii. 768 (Abs.)
J. Dechant	Über den Gang der Lichtstrahlen durch Glasröhren, die mit Flüssigkeit gefüllt sind, und eine darauf sich gründende Methode, den Brechungsexponenten condensirter Gase zu bestimmen. (Read Oct. 16.)	'Sitzungsb. Wien. Akad.' xc. II. 539–550; 'Monatshefte,' v. 615–626; 'J. Chem. Soc.' xlviii. 621 (Abs.)
C. Christiansen	Untersuchungen über die optischen Eigenschaften von fein vertheilten Körpern.	'Ann. Phys. u. Chem.' N.F. xxiii. 298–306.
A. Albitsky	Ueber das Brechungsvermögen des aus Allyldimethylcarbinol sich bildenden Kohlenwasserstoffs $C_{12}H_{20}$.	'J. pr. Chem.' xxx. 213–214; 'Ber.' xviii. Referate, 53 (Abs.); 'Beiblätter,' ix. 114 (Abs.); 'J. Chem. Soc.' xlviii. 211 (Abs.)
J. Violle	Sur l'étalon absolu de lumière	'Ann. Chim. et Phys.' [6] iii. 373–407; 'Zeitschr. f. Instrumentenkunde,' v. 92–95 (Abs.)
C. Soret	Recherches sur la réfraction et la dispersion dans les aluns cristallisés. (Soc. de phys., Genève. Read Nov. 6.)	'Archives de Genève [3] xii. 553–584; xiii. 5–33; 'J. de Phys.' [2] v. 287–288 (Abs.)
A. König	Ueber Farbensehen und Farbenblindheit. (Read Nov. 14.)	'Verh. physiol. Ges. Berlin, Arch. f. Anat. und Physiol., Physiol. Abth., 1885, 160–164; 'Nature,' xxxi. 187–188 (Abs.)
C. Soret	Indices de réfraction des aluns cristallisés. (Read Nov. 17.)	'C. R.' xcix. 867–869, 1000; 'J. Chem. Soc.' xlviii. 109 (Abs.); 'Beiblätter,' ix. 115–116 (Abs.)
H. Parinaud	De l'intensité lumineuse des couleurs spectrales; influence de l'adaptation rétinienne. (Read Nov. 24.)	'C. R.' xcix. 937–939; 'Beiblätter,' ix. 341 (Abs.)
F. C. Donders	Farbengleichungen. I. Mischungen von Roth (λ 0·6705μ) und Grün (λ 0·535μ).	'Archiv f. Anatomie u. Physiol.' 1884, 'Physiol. Abtheilung,' 518–552; 'Beiblätter,' ix. 431–432 (Abs.)

PHYSICAL RELATIONS, 1884, 1885.

H. Dufet . .	Remarques sur les propriétés optiques des mélanges isomorphes. (Read Dec. 1.)	'C. R.' xcix. 990–992.
G. Krüss . .	Ueber den Einfluss der Temperatur auf spektralanalytische Beobachtungen und Messungen. (Recd. Nov. 25. Read Dec. 8.)	'Ber.' xvii. 2732–2739; 'Beiblätter,' ix. 118 (Abs.); 'J. Chem. Soc.' xlviii. 209–210 (Abs.); 'Am. J.' [3] xxix. 251–252 (Abs.); 'Zeitschr. anal. Chem.' xxv. 536–537 (Abs.); 'Chem. News,' lv. 233 (Abs.)

1885.

W. N. Hartley .	The Influence of Atomic Arrangement on the Physical Properties of Compounds.	'Phil. Mag.' [5] xix. 55–57; 'Beiblätter,' ix. 147 (Abs.)
J. H. Gladstone .	On the present state of our knowledge of Refraction Equivalents.	'Am. J.' [3] xxix. 55–57 'Beiblätter,' ix. 417–418 (Abs.)
R. Nasini . .	Sulla rifrazione atomica dello zolfo. (Read Jan. 18.)	'Atti R. Accad. d. Lincei, Rendiconti' i. 74–78; 'Ber.' xviii. Referate, 254 (Abs.); 'Beiblätter,' ix. 324–325 (Abs.)
" . .	Sul valore più elevato della rifrazione atomica del carbonio. (Read Jan. 18.)	'Atti R. Accad. d. Lincei, Rendiconti' i. 78–82; 'Ber.' xviii. Referate, 255 (Abs.); 'Beiblätter,' ix. 330–332 (Abs.)
F. Vogel . .	Aenderung der Lichtbrechung in Glas und Kalkspath mit der Temperatur. (Jan. 1885.)	'Ann. Phys. u. Chem.' N.F. xxv. 87–94.
G. G. Stokes .	On a remarkable Phenomenon of Crystalline Reflection. (Recd. Feb. 25. Read Feb. 26.)	'Proc. Roy. Soc.' xxxviii. 174–185; 'Nature,' xxxi. 565–568; 'Beiblätter,' ix. 337–339 (Abs.); 'J. Chem. Soc.' xlviii. 1175–1176 (Abs.)
H. Lagarde . .	Recherches photométriques sur le spectre de l'hydrogène.	'Ann. Chim. et Phys. [6] iv. 248–370.
W. de W. Abney .	Recent Researches on Radiation. (Phys. Soc., March 14.)	'Nature,' xxxi. 523 (Abs.); 'Am. J.' [3] xxx. 494 (Abs.)
F. C. Donders. .	Équations de couleurs spectrales simples et de leurs mélanges binaires dans les systèmes normal (polychromatique) et anormaux (dichromatiques).	'Arch. Néerlandaises,' xix. 303–346.
A. C. Oudemans, jun.	Over de Densiteit, den uitzettingscoëfficient en den Breckingsaanwijzer van Aethylaether.	'Versl. en Mededeelingen Kgl. Ak. Wetensch. Amsterdam,' [3] i. 426–468; 'Beiblätter,' ix. 618–620 (Abs.)
L. Arons . .	Interferenzstreifen im Spectrum .	'Ann. Phys. u. Chem.' N.F. xxiv 669–670.

Physical Relations, 1885.

J. M. Eder	Spectrographische Untersuchung von Normal-Lichtquellen und die Brauchbarkeit der letzteren zu photochemischen Messungen der Lichtempfindlichkeit. (Read April 23.)	'Monatshefte,' vi. 363–368; 'Wien. Anz.' 1885, 93 (Abs.); 'J. Chem. Soc.' xlviii. 1026 (Abs.); 'Beiblätter,' ix. 629–630 (Abs.)
C. Fievez	De l'influence du magnétisme sur les caractères des raies spectrales. (Read May 5.)	'Bull. Acad. Belg.' [3] ix. 381–384; 'Nature,' xxxii. 358–359 (Abs.); 'Chem. News,' lii. 302–303; 'Beiblätter,' ix. 752–753 (Abs.)
J. v. Hepperger	Über Krümmungsvermögen und Dispersion von Prismen. (Read May 7.)	'Sitzungsb. Wien. Akad.' xcii. II. 261–300; 'Wien. Anz.' 1885, 109–110 (Abs.); 'Beiblätter,' x. 352 (Abs.)
A. Cornu	Sur les raies spectrales spontanément renversables et l'analogie de leurs lois de répartition et d'intensité avec celles des raies de l'hydrogène. (Read May 11.)	'C. R.' c. 1181–1188; 'Chem. News,' li. 262 (Abs.); 'J. Chem. Soc.' xlviii. 853 (Abs.); 'Beiblätter,' ix. 517–519 (Abs.)
J. Macé de Lépinay	Applications des spectres cannelés de Fizeau et Foucault.	'J. de Phys.' [2] iv. 261–271; 'Beiblätter,' ix. 790–792 (Abs.)
J. Kanonnikoff	Untersuchungen über das Lichtbrechungsvermögen chemischer Verbindungen.	'J. pr. Chem.' [2] xxxi. 321–363; 'Chem. News,' lii. 94 (Abs.); 'Ber.' xviii. Referate, 425 (Abs.)
C. Soret	Recherches sur la réfraction et la dispersion dans les aluns cristallisés. (Soc. de Phys., Genève. Read June 4.)	'Archives de Genève' [3] xiv. 96; 'J. de Phys.' [2] v. 287–288 (Abs.)
J. H. Gladstone	On the Specific Refraction and Dispersion of Light by the Alums. (Read June 27.)	'Proc. Phys. Soc.' vii. 194–200; 'Phil. Mag.' [5] xx. 162–168; 'Nature,' xxxii. 263 (Abs.); 'Chem. News,' lii. 22 (Abs.); 'Beiblätter,' ix. 625–627 (Abs.); 'J. Chem. Soc.' l. 293 (Abs.)
N. von Klobulow	Zur Frage über den Zusammenhang zwischen Molecularstructur und Lichtabsorptionserscheinungen. (June 27.)	'J. pr. Chem.' xxxii. 122–125.
G. Müller	Ueber den Einfluss der Temperatur auf die Brechung des Lichtes in einigen Glassorten, im Kalkspath und Bergkrystall.	'Publ. Astrophys. Obs. Potsdam,' iv. 151–216; 'Beiblätter,' x. 279–281 (Abs.)
R. Sissingh	Mesures de la polarisation elliptique de la lumière.	'Arch. néerlandaises,' xx. 171–238; 'Beiblätter,' x. 175–180 (Abs.)

PHYSICAL RELATIONS, 1885.

E. Mach and J. Arbes.	Einige Versuche über totale Reflexion und anomale Dispersion. (Read July 9.)	'Sitzungsb. Wien. Acad. xcii. II. 416–426; 'Ann. Phys. u. Chem.' N.F. xxvii. 436–444.
H. Dufet . .	Recherches expérimentales sur la variation des indices de réfraction sous l'influence de la chaleur. (Read July 9.)	'Bull. Soc. Min. de France,' viii. 171–204; 'J. de Physique' [2], iv. 389–419; 'Beiblätter,' x. 282–288 (Abs.); 'Am. J. Sci.' [3] xxxi. 59–60 (Abs.); 'Nature,' xxxiii. 309 (Abs.)
C. Soret . . .	Indices de réfraction de quelques aluns cristallisés. (Read July 13.)	'C. R.' ci. 156–157; 'J. Chem. Soc.' xlviii. 1097 (Abs.); 'Beiblätter,' x. 695 (Abs.)
A. Charpentier .	Sur la distribution de l'intensité lumineuse et de l'intensité visuelle dans le spectre solaire. (Read July 13.)	'C. R.' ci. 182–183.
E. Lommel . .	Sichtbare Darstellung des Brennpunktes der ultrarothen Strahlen durch Phosphorescenz. (Read July 13.)	'Sitzungsb. phys.-med. Soc. Erlangen,' 1885, 38–39; 'Ann. Phys. u. Chem.' N.F. xxvi. 157–159; 'Phil. Mag.' [5] xx. 547–548; 'J. Chem. Soc.' l. 5 (Abs.); 'Am. J.' [3] xxxi. 150–151 (Abs.)
G. Griffith . .	On the Formation of a Pure Spectrum by Newton. (Read Sept. 16.)	'Brit. Assoc. Report,' 1885, 940–942; 'Beiblätter,' xii. 193 (Abs.)
A. S. Herschel .	On the Use of Bisulphide of Carbon Prisms for cases of Extreme Spectroscopic Dispersion, by Professor C. Piazzi Smyth; and their Results in Gaseous Spectra, commented on. (Read Sept. 16.)	'Brit. Assoc. Report,' 1885, 942–944; 'Beiblätter,' xii. 336–337 (Abs.)
P. Glan . . .	Ein Grundgesetz der Complementärfarben. (Read Oct. 8.)	'Sitzungsb. Wien. Akad.' xcii. II. 906–913; 'Beiblätter,' x. 170–171 (Abs.)
Schrauf . . .	Dispersionsäquivalent des Diamant. (Oct. 24, 1885.)	'N. Jahrb. f. Mineral.' 1886, i. 93.
Macé de Lépinay .	Dispersion de double réfraction du quartz. (Read Nov. 2.)	'C. R.' ci. 874–876; 'Beiblätter,' x. 174–175 (Abs.)
G. Gladstone . .	On the Refraction of Fluorine .	'Phil. Mag.' [5] xx. 481–483; 'Ber.' xix. Referate, 4 (Abs.); 'J. Chem. Soc.' l. 497 (Abs.); 'Beiblätter,' x. 567–568 (Abs.)
S. P. Langley .	Note on the Optical Properties of Rock-salt.	'Am. J.' [3] xxx. 477–481; 'Beiblätter,' x. 495 (Abs.)
J. Kanonnikoff .	Untersuchungen über das Lichtbrechungsvermögen chemischer Verbindungen. (II. Abhandlung.)	'J. pr. Chem.' N.F. xxxii. 497–523; 'Ber.' xix. Referate, 4 (Abs.); 'J. Chem. Soc.' l. 335–336 (Abs.)

PHYSICAL RELATIONS, 1885, 1886.

A. Crova . .	Comparaison photométrique des lumières de teintes différentes.	'Ann. Chim. et Phys.' [6] vi. 528–545.
A. Schrauf . .	Ueber das Dispersionsäquivalent von Schwefel. (Dec. 1885.)	'Ann. Phys. u. Chem.' N.F, xxvii. 300–314; 'J. Chem. Soc.' l. 406 (Abs.)

1886.

W. Lermantoff .	Démonstration géometrique des conditions du minimum de déviation d'un rayon par le prisme. (In Russian.)	'J. soc. phys.-chim. russe, xviii. 12–14; 'Beiblätter,' xi. 32–33 (Abs.)
S. P. Langley .	Observations on Invisible Heat-spectra and the recognition of hitherto unmeasured Wave-lengths, made at the Alleghany Observatory. (Am. Assoc.)	'Am. J.' [3] xxxi. 1–12; 'Nature,' xxxiii. 332 (Abs.); 'Beiblätter,' xi. 245–248 (Abs.)
Langley . . .	Sur des longueurs d'onde jusqu'ici non reconnues. (Read Jan. 18.)	'C. R.' cii. 162–164; 'Nature,' xxxiii. 312 (Abs.); 'Chem. News,' liii. 72 (Abs.)
H. G. Madan . .	Note on some Organic Substances of High Refractive Power. (Read Jan. 23.)	'J. Phys. Soc.' vii. 364–366; 'Phil. Mag.' [5] xxi. 245–248; 'Chem. News,' liii. 58 (Abs.); 'Nature,' xxxiii. 335 (Abs.); 'Beiblätter,' x. 568 (Abs.)
H. Becquerel . .	Observations relatives à une Note de M. Langley, sur des longueurs d'onde jusqu'ici non reconnues. (Read Jan. 25.)	'C. R.' cii. 209–210; 'Nature,' xxxiii. 336 (Abs.); 'Chem. News,' liii. 72–73 (Abs.); 'Beiblätter,' x. 411–412 (Abs.)
G. Müller and P. Kempf	Bestimmung der Wellenlängen von 300 Linien im Sonnenspectrum.	'Publ. astrophys. Obs. Potsdam,' v. 1–281; 'Nature,' xxxiv. 176 (Abs.); 'Beiblätter,' x. 499 (Abs.)
A. Cornu . .	Sur les raies spectrales spontanément renversables et l'analogie de leurs lois de répartition et d'intensité avec celles des raies de l'hydrogène.	'J. de Phys.' [2] v. 93–100; 'Nature,' xxxiv. 105–106 (Abs.)
W. de W. Abney and R. Festing	Colour Photometry. (The Bakerian Lecture. Recd. Feb. 18. Read March 4.)	'Phil. Trans.' clxxvii. 423–456; 'Proc. Roy. Soc.' xl. 238–239 (Abs.); 'Nature,' xxxiii. 525–526 (Abs.); 'Chem. News,' liii. 121 (Abs.); 'Beiblätter,' xii. 340–341 (Abs.)
E. van Aubel . .	Note sur la transparence du platine. (April 1886.)	'Bull. acad. belg.' [3] xi. 408–414; 'Beiblätter,' xi. 435–437 (Abs.)
H. G. Madan . .	On the Effect of Heat in changing the Structure of Crystals of Potassium Chlorate. (May 10.)	'Nature,' xxxiv. 66–67.
W. de W. Abney and R. Festing	Intensity of Radiation through Turbid Media. (Recd. May 3. Read May 13.)	'Proc. Roy. Soc.' xl. 378–380; 'Beiblätter,' x. 622 (Abs.)

PHYSICAL RELATIONS, 1886.

J. Macé de Lépinay	Détermination de la valeur absolue de la longueur d'onde de la raie D_2. (Read May 24.)	'C. R.' cii. 1153–1155; 'Nature,' xxxiv. 116 (Abs.); 'Beiblätter,' x. 567 (Abs.)
S. P. Langley .	On hitherto unrecognised Wave-lengths. (May 31.)	'Am. J.' [3] xxxii. 83–106; 'Nature,' xxxiv. 402 (Abs.); 'Beiblätter,' xi. 245–248 (Abs.); 'Zeitschr. f. Instrumentenkunde,' vi. 432–434 (Abs.)
P. Garbe . .	Recherches expérimentales sur le rayonnement.	'J. de Phys.' [2] v. 245–258.
Gouy . . .	Recherches expérimentales sur la diffraction.	'Ann. Chim. et Phys. [6] viii.145–192; 'Beiblätter,' xi. 95–99 (Abs.)
J. H. Gladstone .	On Essential Oils. Part III. Their Specific Refractive and Dispersive Energy. (Read June 17.)	'J. Chem. Soc.' xlix. 609–623; 'Ber.' xix. Referate, 807–808 (Abs.); 'Beiblätter,' xi. 771 (Abs.)
R. Nasini and A. Scala	Sulla rifrazione moleculare dei sulfocianati, degli isosulfocianati e del tiofene. (Read June 20.)	'Rend. R. Acc. Lincei,' [4] ii. 1st semestre, 617–623; 'Gazz. chim. ital.' xvii. 66–72; 'Beiblätter,' x. 695–698 (Abs.); 'Ber.' xx. Referate, 193–194 (Abs.); 'J. Chem. Soc.' lii. 754 (Abs.)
"	Sulla rifrazione molecolare di alcuni derivati del solfuro di carbonio. (Read June 20.)	'Rend. R. Acc. Lincei, [4] ii. 1st semestre, 623–628; 'Gazz. chim. ital.' xvii. 72–78; 'Beiblätter,' x. 695–698 (Abs.); 'Ber.' xx. Referate, 194–195 (Abs.); 'J. Chem. Soc.' lii. 753–754 (Abs.)
J. Chappuis and C. Rivière . .	Sur la réfraction de l'air. (Read June 21.)	'C. R.' cii. 1461–1462; 'Beiblätter,' x. 495–496 (Abs.)
J. W. Brühl . .	Untersuchungen über die Molekularrefraction organischer flüssiger Körper von grossem Farbenzerstreuungsvermögen. (June 1886.)	'Ann. der Chemie,' ccxxxv. 1–106; 'Chem. News,' liv. 213–214 (Abs.); 'J. Chem. Soc.' lii. 191–195 (Abs.); 'Beiblätter,' xi. 240–244 (Abs.)
B. Hasselberg .	Sur une méthode propre à déterminer avec grande précision les longueurs d'onde des raies ultraviolettes du spectre solaire.	'Mem. spettr. ital.' xv. 127–133.
J. W. Brühl .	Experimentelle Prüfung der älteren und der neueren Dispersionsformeln.	'Ann. der Chem.' ccxxxvi. 233–290; 'Chem. News,' lv. 70 (Abs.); 'Beiblätter,' xi. 244 (Abs.)
E. Spée . .	Quelques remarques sur les spectres de diffraction. (Read July 3.)	'Bull. acad. roy. belg. [3] xii. 32–34; 'Beiblätter,' xi. 99 (Abs.)

PHYSICAL RELATIONS, 1886.

J. Chappuis and C. Rivière	Sur la réfraction de l'acide carbonique et du cyanogène. (Read July 5.)	'C. R.' ciii. 37–39; 'Nature,' xxxiv. 260 (Abs.); 'J. Chem. Soc.' l. 837 (Abs.); 'Ber.' xix. Referate, 649 (Abs.); 'Beiblätter,' xi. 91–92 (Abs.); 'Am. J.' [3] xxxiii. 151 (Abs.)
M. Langley . .	Sur les spectres invisibles. (July 17.)	'Ann. Chim. et Phys.' [6] ix. 433–506.
Gouy . . .	Sur la vitesse de la lumière dans le sulfure de carbone. (Read July 26.)	'C. R.' ciii. 244–245; 'J. Chem. Soc.' l. 957 (Abs.)
C. Koechlin . .	Sur le pourpre du spectre solaire. (Read Aug. 23.)	'C. R.' ciii. 432–434; 'Nature,' xxxiv. 436 (Abs.); 'Chem. News,' liv. 171.
E. C. Pickering .	Comparison of Maps of the Ultra Violet Spectrum.	'Am. J.' [3] xxxii. 223–226; 'Nature,' xxxiv. 540 (Abs.); 'Beiblätter,' xi. 145–146 (Abs.)
J. H. Gladstone .	The Essential Oils: a Study in Optical Chemistry. (Brit. Assoc., Sept. 1886.)	'Chem. News,' liv. 323.
S. Czapski . .	Mittheilungen über das glastechnische Laboratorium in Jena und die von ihm hergestellen neuen optischen Gläser.	'Zeitsch. f. Instrumentenkunde,' vi. 293–299, 335–348.
E. Spée . . .	Sur les spectres de diffraction. (Read Oct. 9.)	'Bull. acad. belg.' [3] xii. 439–440; 'Beiblätter,' xi. 786 (Abs.)
J. W. Brühl . .	Untersuchungen über die Molecularrefraction organischer flüssiger Körper von grossem Farbenzerstreuungsvermögen. (Read Oct. 25.)	'Ber.' xix. 2746–2762; 'J. Chem. Soc.' lii. 191–195 (Abs.); 'Beiblätter,' xi. 240–244 (Abs.)
	The New Optical Glass.	'Nature,' xxxiv. 622–623.
J. W. Brühl . .	Experimentelle Prüfung der älteren und der neueren Dispersionsformeln. (Oct. 1886. Read Nov. 8.)	'Ber.' xix. 2821–2837; 'J. Chem. Soc.' lii. 195–198 (Abs.); 'Beiblätter,' xi. 244 (Abs.)
J. Thomsen . .	Ueber den vermeintlichen Einfluss der mehrfachen Bindungen auf die Molecularrefraction der Kohlenwasserstoffe. (Oct. 1886. Read Nov. 8.)	'Ber.' xix. 2837–2843; 'J. Chem. Soc.' lii. 198–200 (Abs.)
G. Krüss . .	Ueber den Einfluss der Temperature auf spectral-analytische Beobachtungen und Messungen.	'Ann. Chem. u. Pharm.' ccxxxviii. 57–66; 'Chem. News,' lvi. 51–52 (Abs.)
E. van Aubel . .	Quelques mots sur la transparence du platine et des miroirs de fer, nickel, cobalt, obtenus par électrolyse.	'Bull. acad. belg.' [3] xii. 665–671; 'Beiblätter,' xi. 435–437 (Abs.)
A. Handl . .	Ueber den Farbensinn der Thiere und die Vertheilung der Energie im Spectrum. (Read Dec. 9.)	'Sitzungsb. Wien. Akad.' xciv. II. 935–946; 'Wien. Anz.' 1886, 235–236 (Abs.); 'Beiblätter,' xi. 585 (Abs.)

PHYSICAL RELATIONS, 1886, 1887.

J. W. Brühl . .	Ueber Herrn Julius Thomsen's vermeintliche Aufklärung der Molecularrefractions-Verhältnisse. (Read Dec. 13.)	'Ber.' xix. 3103–3108; 'J. Chem. Soc.' lii. 200 (Abs.)
	1887.	
J. Macé de Lépinay	Méthode pour mesurer en longueurs d'onde de petites épaisseurs.	'Ann. Chim. et Phys.' [6] x. 68–85; 'Beiblätter,' xi. 442–443 (Abs.)
"	Détermination de la valeur absolue de la longueur d'onde de la raie D_2.	'Ann. Chim. et Phys.' [6] x. 170–200; 'Beiblätter,' xi. 641–642 (Abs.)
R. Nasini . .	Sulla rifrazione moleculare delle sostanze organiche dotate di forte potere dispersivo. (Note I. Read Feb. 6. Note II. Feb. 20.)	'Rend. Acc. Roma,' [4] iii. 1st semestre, 128–133, 164–172; 'Gazz. chim. ital.' xvii. 48–55, 55–64; 'Ber.' xx. Referate, 498 (Abs.); 'Beiblätter,' xi. 579–580 (Abs.)
— Negreano . .	Recherches sur le pouvoir inducteur spécifique des liquides. (Read Feb. 14.)	'C. R.' civ. 423–425; 'J. Chem. Soc.' lii. 413 (Abs.)
G. Meyer . .	Notiz über den Brechungsquotienten des Eises. (Feb. 1887.)	'Ann. Phys. u. Chem.' N.F. xxxi. 321–322; 'J. Chem. Soc.' lii. 753 (Abs.)
E. Ketteler . .	Zur Dispersion des Steinsalzes. (Feb. 1887.)	'Ann. Phys. u. Chem.' N.F. xxxi. 322–326; 'Nature,' xxxvi. 165 (Abs.); 'Am. J.' [3] xxxiv. 67 (Abs.); 'J. Chem. Soc.' lii. 754–755 (Abs.)
L. Bell . . .	On the Absolute Wave-length of Light.	'Am. J.' xxxiii. 167–182; 'Phil. Mag.' [5] xxiii. 265–282; 'Nature,' xxxv. 524 (Abs.); 'Beiblätter,' xi. 820–821 (Abs.)
H. A. Rowland .	On the Relative Wave-length of the Lines of the Solar Spectrum.	'Am. J.' xxxiii. 182–190; 'Phil. Mag.' [5] xxiii. 257–265; 'Nature,' xxxv. 524 (Abs.); 'Beiblätter,' xi. 777–778 (Abs.)
J. Macé de Lépinay	Indices du quartz dans le spectre visible.	'J. de Phys.' [2] vi. 190–196; 'Beiblätter,' xi. 786–787 (Abs.)
Deslandres . .	Loi de répartition des raies et des bandes, commune à plusieurs spectres de bandes. Analogie avec la loi de succession des sons d'un corps solide. (Read April 4.)	'C. R.' civ. 972–976; 'Nature,' xxxv. 576 (Abs.); 'Chem. News,' lv. 204–205 (Abs.); 'Beiblätter,' xii. 47–48 (Abs.)
O. Wiener . .	Ueber die Phasenänderung des Lichtes bei der Reflexion und Methoden zur Dickenbestimmung dünner Blättchen.	'Ann. Phys. u. Chem.' N.F. xxxi. 629–672.
J. Chappuis and C. Rivière.	Sur la compressibilité du cyanogène comparée à sa réfraction. (Read May 23.)	'C. R.' civ. 1433–1435; 'Nature,' xxxvi. 119 (Abs.); 'J. Chem. Soc.' lii. 753 (Abs.)

PHYSICAL RELATIONS, 1887.

J. W. Brühl	Ueber den Einfluss der einfachen und der sogenannten mehrfachen Bindung der Atome auf das Lichtbrechungsvermögen der Körper. Ein Beitrag zur Erforschung der Konstitution der Benzol- und der Naphthalinverbindungen. (May 1887.)	'Zeitschr. f. physikal. Chem.' i. 307–361; 'Beiblätter,' xi. 771–774 (Abs.)
H. F. Weber	'Die Entwickelung der Lichtemission glühender fester Körper. (Read June 9.)	'Sitzungsb. Berlin. Akad.' 1887, 491–504; 'Ann. Phys. u. Chem.' N.F. xxxii. 256–275.
J. H. Gladstone	Dispersion Equivalents. Part I. (Recd. May 24. Read June 16.)	'Proc. Roy. Soc.' xlii. 401–410; 'Chem. News,' lv. 300–304; 'Ber.' xx. Referate, 494 (Abs.); 'Beiblätter,' xi. 698–700 (Abs.); 'Nature,' xxxvi. 239 (Abs.); 'J. Chem. Soc.' liv. 389 (Abs.)
J. W. Brühl	Ueber den Einfluss der einfachen und der sogenannten mehrfachen Bindung der Atome auf das Lichtbrechungsvermögen der Körper. Ein Beitrag zur Erforschung der Constitution der Benzol- und der Naphthalinverbindungen. (Recd. July 20. Read July 25.)	'Ber.' xx. 2288–2311; 'J. Chem. Soc.' lii. 1005 (Abs.)
A. Winkelmann	Notiz zur anomalen Dispersion glühender Metalldämpfe. (July 1887.)	'Ann. Phys. u. Chem.' N.F. xxxii. 439–442; 'J. Chem. Soc.' liv. 207–208 (Abs.)
L. Bell	Recent Determinations of Absolute Wave-length. (Brit. Assoc.)	'Nature,' xxxvi. 524 (Abs.); 'Am. J.' [3] xxxiv. 400 (Abs.)
J. H. Gladstone	Dispersion Equivalents and Constitutional Formulæ. (Brit. Assoc.)	'Nature,' xxxvi. 570 (Abs.)
E. Ketteler	Experimentaluntersuchung über das Refractionsvermögen der Flüssigkeiten zwischen sehr entfernten Temperaturgrenzen. (Oct. 1887.)	'Ann. Phys. u. Chem.' N.F. xxxiii. 353–381; 506–534; 'J. Chem. Soc.' liv. 541–542 (Abs.)
A. E. Nordenskiöld	Sur un rapport simple entre les longueurs d'onde des spectres. (Read Nov. 21.)	'C. R.' cv. 988–995; 'Nature,' xxxvii. 120 (Abs.); 'Chem. News,' lvi. 268–269 (Abs.)
A. A. Michelson and E. W. Morley.	On a Method of making the Wave-length of Sodium Light the actual and practical standard of length.	'Am. J.' [3] xxxiv. 427–430; 'Phil. Mag.' [5] xxiv. 463–466; 'Beiblätter,' xii. 477–478 (Abs.)
H. G. Madan	On the Optical Properties of Phenyl-thio-carbimide. (Read Dec. 10.)	'Proc. Phys. Soc.' ix. 262–263 (Abs.); 'Nature,' xxxvii. 165 (Abs.); 'Chem. News,' lvi. 257–258 (Abs.)

PHYSICAL RELATIONS, 1888.

K. Seubert .	Die Benzylester der chlorsubstituirten Essigsaüren. (Recd. Jan. 19. Read Jan. 22.)	'Ber.' xxi. 281–285; 'Beiblätter,' xii. 234–235 (Abs.)
J. W. Brühl .	Untersuchungen über die Terpene und deren Abkömmlinge. (I. Mittheilung.) (Rec. Dec. 30, 1887. Read Jan. 22, 1888.)	'Ber.' xxi. 145–179; 'J. Chem. Soc.' liv. 377–378 (Abs.)
A. Kundt . .	Ueber die Brechungsexponenten der Metalle (Read Feb. 2.)	'Sitzungsb. Berlin. Akad.' viii. 255–272; 'Ann. Phys. u. Chem.' N.F. xxxiv. 469–489; 'Phil. Mag.' [5] xxvi. 1–18; 'J. Chem. Soc.' liv. 997–999 (Abs.)
E. Brücke .	Ueber der optischen Eigenschaften der Tabashier. (Read Feb. 9.)	'Sitzungsb. Wien. Akad.' xcvii. I. 69–82; 'Beiblätter,' xii. 665–666 (Abs.)
T. Pelham Dale .	On the Numerical Relation between the Index of Refraction and the Wave-length within a Refractive Medium, and on the Limit of Refraction. (Read Feb. 11.)	'Proc. Phys. Soc.' ix. 167–181; 'Phil. Mag.' [5] xxv. 325–338.
J. W. Brühl . .	Untersuchungen über die Terpene und deren Abkömmlinge. (II. Mittheilung.) (Recd. Jan. 17. Read Feb. 13.)	'Ber.' xxi. 457–477.
H. Ebert . .	Die Methode der hohen Interferenzen in ihrer Verwendbarkeit für Zwecke der quantitativen Spectralanalyse. (Feb. 1888.)	'Ann. Phys. u. Chem.' N.F. xxxiv. 39–90; 'J. Chem. Soc.' liv. 766–768 (Abs.)
L. Zehnder . .	Ueber den Einfluss des Druckes auf den Brechungsexponenten des Wassers für Natriumlicht. (Feb. 16, 1888.)	'Ann. Phys. u. Chem.' N.F. xxxiv. 91–121; 'J. Chem. Soc.' liv. 765 (Abs.); 'Ber.' xxi. Referate, 338 (Abs.)
L. Godard . .	Sur les coefficients de proportionnalité en chaleur rayonnante. (Read Feb. 20.)	'C. R.' cvi. 545–547; 'Nature,' xxxvii. 432 (Abs.)
O. Wallach . .	Ueber die Benutzbarkeit der Molecularrefraction für Constitutionsbestimmungen innerhalb der Terpengruppe. (Recd. Feb. 28.)	'Ann. d. Chem.' ccxlv. 191–213; 'J. Chem. Soc.' liv. 845 (Abs.); 'Ber.' xxi. Referate, 342 (Abs.)
R. Weegmann .	Über die Molekularrefraktion einiger gebromter Äthane und Äthylene und über den gegenwärtigen Stand der Landolt-Brühl'schen Theorie.	'Zeitschr. f. physikal. Chem.' ii. 218–240, 257–269; 'J. Chem. Soc.' liv. 999–1000 (Abs.); 'Ber.' xxi. Referate, 341 (Abs.), 390 (Abs.); 'Beiblätter,' xii. 779–782 (Abs.)
J. Chappuis and C. Rivière.	Sur la réfraction des gaz comparée à leur compressibilité.	'Ann. Chim. et Phys.' [6] xiv. 5–36; 'Ber.' xxi. Referate, 423 (Abs.)

PHYSICAL RELATIONS, 1888, 1889.

W. de W. Abney and R. Festing.	Colour Photometry. Part II. Measurement of Reflected Colours. (Recd. May 3. Read May 31.)	'Phil. Trans.' clxxix. 547–570; 'Proc. Roy. Soc.' xliv. 237–239 (Abs.); 'Nature,' xxxviii. 212–213 (Abs.); 'Beiblätter,' xii. 851–852 (Abs.)
J. H. Gladstone and W. Hibbert.	The Optical and Chemical Properties of Caoutchouc. (Read June 7.)	'J. Chem. Soc.' liii. 679–688; 'Chem. News,' lvii. 247 (Abs.); 'Ber.' xxi. Referate, xxi. 573–574 (Abs.)
E. Ketteler . .	Experimentaluntersuchung über das Refractionsvermögen der Flüssigkeiten zwischen sehr entfernten Temperaturgrenzen. (June 1888.)	'Ann. Phys. u. Chem.' N.F. xxxv. 662–699; 'J. Chem. Soc.' lvi. 197 (Abs.)
C. Knops . .	Ueber die Molecularrefraction der Isomerien Fumar- Maleïnsäure, Mesacon- Citracon- Itaconsäure und des Thiophens und ihre Beziehung zur chemischen Constitution dieser Substanzen. (Recd. Aug. 20.)	'Ann. d. Chem.' ccxlviii. 175–231; 'Ber.' xxii. Referate, 86 (Abs.); 'J. Chem. Soc.' lvi. 198 (Abs.)
H. G. Madan . .	A Substitute for Carbon Disulphide in Prisms, &c. (Aug. 28.)	'Nature,' xxxviii. 413–414
Lord Rayleigh .	On the Remarkable Phenomena of Crystalline Reflexion described by Professor Stokes.	'Phil. Mag.' [5] 256–265; 'Beiblätter,' xiii. 319–320 (Abs.)
G. Govi . . .	Sur les couleurs latentes des corps. (Read Oct. 15.)	'C. R.' cvii. 609–612; 'Nature,' xxxviii. 631–632 (Abs.)
T. Pelham Dale .	On the Upper Limit of Refraction in Selenium and Bromine. (Read Nov. 10.)	'Proc. Phys. Soc.' x. 17–23; 'Phil. Mag.' [5] xxvii. 50–56; 'Chem. News,' lviii. 252–253 (Abs.)
W. de W. Abney .	On the Measurement of the Luminosity and Intensity of Light reflected from Coloured Surfaces. (Read Nov. 24.)	'Proc. Phys. Soc.' x. 30–37; 'Phil. Mag.' [5] xxvii. 62–69.
J. H. Long . .	On the Densities and Refractive Indices of certain Oils.	'Amer. Chem. J.' x. 392–405; 'J. Chem. Soc.' lvi. 85–86 (Abs.)
A. Kundt . .	Ueber die Aenderung der Lichtgeschwindigkeit in den Metallen mit der Temperatur. (Read Dec. 13.)	'Sitzungsb. Berlin. Akad.' 1888, 1387–1394; 'Ann. Phys. u. Chem.' N.F. xxxvi. 824–833; 'J. Chem. Soc.' lvi. 749–750 (Abs.)

1889.

G. Ciamician . .	Ueber die physikalischen Eigenschaften des Benzols und des Thiophens. (Recd. Jan. 9. Read Jan. 14.)	'Ber.' xxii. 27–30.
C. C. Hutchins .	Notes on Metallic Spectra. (March 14.)	'Am. J.' [3] xxxvii. 474–476; 'Nature,' xl. 189 (Abs.)

PHYSICAL RELATIONS, 1889.—FLUORESCENCE, 1882, 1883, 1884, 1885.

E. Carvallo . .	Formule de Briot appliquée à la dispersion dans le sel gemme.	'J. de Phys' [2] viii. 179–183.
O. Wallach . .	Ueber die Molecularrefraction des Camphens.	'Ann. d. Chem.' cclii. 136–140.
H. A. Rowland .	Table of Standard Wave-lengths .	'Johns Hopkins' Univ. Circ.' No. 73, p. 78: 'Phil. Mag.' [5], xxvii. 479–484.
A. Cornu . .	Résultats numériques obtenus dans l'étude de la réflexion vitreuse et métallique des radiations visibles et ultra-violettes. (Read June 17.)	'C. R.' cviii. 1211–1217; 'Nature,' xl. 215–216 (Abs.)
P. Barbier and L. Roux.	Recherches sur la dispersion dans les composés organiques. (Read June 17.)	'C. R.' cviii. 1249–1251.

FLUORESCENCE.

1882.

E. Linhardt . .	Ueber Fluorescenz erster Art. (Inaug. Dissert. Erlangen 1882.)	'Beiblätter,' vii. 600–604 (Abs.)

1883.

H. Becquerel . .	Études des radiations infra-rouges au moyen des phénomènes de phosphorescence. (Read April 23.)	'C. R.' xcvi. 1215–1218.
E. Lommel . .	Phosphorescenz des Kalkspats. (Read Dec. 10.)	'Sitzungsb. phys.-med. Soc. Erlangen,' No. 16, 13–17; 'Ann. Phys. u. Chem.' N.F. xxi. 422–427; 'J. Chem. Soc.' xlvi. 649–650 (Abs.)

1884.

„ . .	Beobachtungen über Fluorescenz. (Read Dec. 6.)	'Sitzungsb. Akad. München,' xiv. 605–610; 'Ann. Phys. u. Chem.' N.F. xxiv. 288–292.

1885.

A. Weiss . .	Über die Fluorescenz der Pilzfarbstoffe. (Read May 15.)	'Sitzungsb. Wien. Akad.' xci. I. 446–447; 'Wien. Anz.' 1885, 111–112 (Abs.); 'Chem. Centr.' 1886, 670–671; 'J. Chem. Soc.' lii. 314 (Abs.)
K. Wesendonck .	Ueber die Fluorescenz des Naphtalinrothes.	'Ann. Phys. u. Chem.' N.F. xxvi. 521–527; 'J. Chem. Soc.' l. 585 (Abs.)
H. Becquerel . .	Relations entre l'absorption de la lumière et l'émission de la phosphorescence dans les composés d'uranium. (Read Dec. 14.)	'C. R.' ci. 1252–1256; 'Nature,' xxxiii. 192 (Abs.); 'Chem. News,' liii. 11 (Abs.); 'J. Chem. Soc. l. 189–190 (Abs.); 'Beiblätter,' x. 410–411 (Abs.)

FLUORESCENCE, 1886, 1887, 1888.

1886.

H. Becquerel . .	Sur les variations des spectres d'absorption et des spectres d'émission par phosphorescence d'un même corps. (Read Jan. 11.)	'C. R.' cii. 106–110; 'Chem. News,' liii. 77–78; 'Beiblätter,' x. 500–501 (Abs.)
C. V. Zenger . .	Études phosphorographiques pour la reproduction photographique du ciel. (Read Feb. 22.)	'C. R.' cii. 408–410; 'Nature,' xxxiii. 431 (Abs.)
F. Stenger . .	Zur Kenntniss der Fluorescenzerscheinungen.	'Ann. Phys. u. Chem.' N.F. xxviii. 201–230; 'Nature,' xxxiv. 355 (Abs.)
C. V. Zenger . .	La phosphorographie appliquée à la photographie de l'invisible. (Read Aug. 30.)	'C. R.' ciii. 454–456; 'Nature,' xxxiv. 463 (Abs.); 'Beiblätter,' xi. 94 (Abs.)
E. Becquerel . .	Action du manganèse sur le pouvoir de phosphorescence du carbonate de chaux. (Read Dec. 6.)	'C. R.' ciii. 1098–1101; 'Nature,' xxxv. 168 (Abs.); 'Chem. News,' liv. 321–322 (Abs.); 'Ber.' xx. Referate, 4–5 (Abs.); 'J. Chem. Soc.' lii. 190 (Abs.); 'Beiblätter,' xi. 342 (Abs.)
. .	Sur la phosphorescence de l'alumine. (Read Dec. 20.)	'C. R.' ciii. 1224–1227; 'Chem. News,' lv. 23 (Abs.); 'J. Chem. Soc.' lii. 191 (Abs.); 'Am. J.' [3] xxxiii. 303–304 (Abs.); 'Beiblätter,' xi. 780–781 (Abs.)

1887.

" . .	Sur la phosphorescence de l'alumine. (Read Feb. 7.)	'C. R.' civ. 334–335; 'Chem. News,' lv. 99–100; 'J. Chem. Soc.' lii. 409–410 (Abs.); 'Beiblätter,' xi. 780–781 (Abs.)
A. Verneuil . .	Sur les causes déterminantes de la phosphorescence du sulfure de calcium. (Read Feb. 21.)	'C. R.' civ. 501–504; 'Nature,' xxxv. 431 (Abs.); 'Chem. News,' lv. 128 (Abs.); 'J. Chem. Soc.' lii. 539–540 (Abs.); 'Beiblätter,' xi. 438 (Abs.)
E. Becquerel . .	Sur la phosphorescence du sulfure de calcium. (Read Feb. 28.)	'C. R.' civ. 551–553; 'Nature,' xxxv. 455 (Abs.); 'Chem. News,' lv. 123–124; 'J. Chem. Soc.' lii. 540 (Abs.); 'Beiblätter,' xi. 539 (Abs.)
Lecoq de Boisbaudran.	À quels degrés d'oxydation se trouvent le chrome et le manganèse dans leurs composés fluorescents? (Read Dec. 19.)	'C. R.' cv. 1228–1233.

1888.

B. Walter . .	Die Aenderungen des Fluorescenzvermögens mit der Concentration. (July 1888.)	'Ann. Phys. u. Chem.' N.F. xxxvi. 502–518; 'J. Chem. Soc.' lvi. 553–554 (Abs.)

FLUORESCENCE, 1888—ASTRONOMICAL APPLICATIONS, 1883, 1884.

B. Walter . .	Ueber den Nachweis des Zerfalles von Moleculargruppen in Lösungen durch Fluorescenz- und Absorptionserscheinungen. (Sept. 1888.)	'Ann. Phys. u. Chem.' N.F. xxxvi. 518–532; 'J. Chem. Soc.' lvi. 554–555 (Abs.)
E. Becquerel . .	Sur la préparation des sulfures de calcium et de strontium phosphorescents. (Read Dec. 3.)	'C. R.' cvii. 892–895; 'J. Chem. Soc.' lvi. 198–199 (Abs.); 'Beiblätter,' xiii. 510 (Abs.)

ASTRONOMICAL APPLICATIONS.

1883.

G. D. Liveing and J. Dewar.	On Sunspots and the Chemical Elements in the Sun. (Read Sept. 20.)	'Brit. Assoc. Report,' 1883. 455; 'Beiblätter,' xi. 639 (Abs.)
C. Fievez . .	Étude du spectre solaire . . .	'Annales de l'obs. roy. de Bruxelles,' iv. 3c–6c; 'Beiblätter,' vi. 938–939 (Abs.)
N. v. Konkoly .	Astrophysikalische Beobachtungen, angestellt auf der Sternwarte Ó-Gyalla im Jahre 1883. (Read Nov. 12.) Das Spectrum von γ Cassiopeiæ. Das Spectrum von α Ursæ Minoris. Das Spectrum des Kometen Brooks.	'Math. u. naturwiss. Ber. Ungarn,' ii. 189–190.
" .	Astrophysikalische Beobachtungen, angestellt auf der Sternwarte Ó-Gyalla im Jahre 1883.	'Math. u. naturwiss. Ber. Ungarn,' ii. 195–197.

1884.

" .	Astrophysikalische Beobachtungen, angestellt auf der Sternwarte Ó-Gyalla im Jahre 1883; 615 Fixsternspectra. (Read Feb. 18.)	'Math. u. naturwiss. Ber. Ungarn,' ii. 198–200.
E. v. Gothard. .	Beobachtungen an dem astrophysikalischen Observatorium zu Herény im Jahre 1883. (Read Feb. 18.)	'Math. u. naturwiss. Ber. Ungarn,' ii. 266–269.
" .	Beobachtungen des Kometen Pons-Brooks an dem astrophysikalischen Observatorium zu Herény. (Read April 21.)	'Math. u. naturwiss. Ber. Ungarn,' ii. 270–272; 'Beiblätter,' x. 623–624 (Abs.)
W. H. Pickering .	Photography of the Infra-red region of the Solar Spectrum. (May 14.)	'Proc. Am. Acad.' xx. 473–477; 'Beiblätter,' x. 29 (Abs.)
H. C. Vogel . .	Einige Beobachtungen mit dem grossen Refractor der Wiener Sternwarte. Spectralanalytische Beobachtungen an Sternen.	'Publicat. des Astrophys. Observatoriums zu Potsdam,' iv. 8–32; 'Beiblätter,' ix. 519 (Abs.); 'Nature,' xxxiii. 376 (Abs.)
P. Tacchini . .	Observations des protubérances solaires, faites à l'observatoire royal du Collége romain pendant l'année 1883. (Read July 15.)	'C. R.' xcix. 72–75.

ASTRONOMICAL APPLICATIONS, 1884, 1885.

H. Becquerel . .	Détermination des longueurs d'onde des raies et bandes principales du spectre solaire infra-rouge. (Read Sept. 1.)	'C. R.' xcix. 417–420; 'Phil. Mag.' [5] xviii. 465–468; 'Chem. News,' l. 163 (Abs.); 'Am. J.' [3] xxviii. 391 (Abs.), xxviii. 457–459; 'Beiblätter,' viii. 818–819 (Abs.); 'Zeitschr. f. Instrumentenkunde,' v. 29–30 (Abs.)
Perrotin . . .	Observations de la comète Barnard et de la planète Luther, faites à l'observatoire de Nice. (Read Sept. 29.)	'C. R.' xcix. 533–534; 'Nature,' xxx. 604 (Abs.)
L. Thollon . .	Constitution et origine du groupe B du spectre solaire.	'J. de Phys.' [2] iii. 421–427.
R. Copeland . .	Spectroscopic Observations made at the Earl of Crawford's Observatory, Dun Echt, Aberdeen. (Dec. 11.)	'Monthly Not. Astr. Soc. xlv. 90–91.
	Spectroscopic Observations made at the Royal Observatory, Greenwich, 1884.	'Greenwich Observations,' 1884, 37 pp.; 'Beiblätter,' xi. 95 (Abs.)
	1885.	
P. Tacchini . .	Sulle osservazioni delle macchie e delle facole solari, eseguite nel R. Osservatorio del Collegio Romano nel 1884. (Read Jan. 18.)	'Atti R. Accad. d. Lincei, Rendiconti,' i. 65–67; 'Nature,' xxxii. 47 (Abs.)
" .	Sulle protuberanze idrogeniche solari osservate al R. Osservatorio de Collegio Romano nel 1884. (Read Feb. 1.)	'Atti R. Accad. d. Lincei, Rendiconti,' i. 103–105; 'Nature,' xxxii. 48 (Abs.)
E. von Gothard .	Die periodische Veränderlichkeit des Spectrums von β Lyrae. (Feb. 6.)	'Astron. Nachr.' cxi. 161–164; 'Nature,' xxxi. 467 (Abs.)
P. Tacchini . .	Observations des protubérances solaires, faites à l'Observatoire du Collége romain pendant l'année 1884. (Read Feb. 9.)	'C. R.' c. 338–340.
C. Michie Smith .	Spectrum of the Zodiacal Light. (Jan. 21. Read Feb. 16.)	'Proc. Roy. Soc. Edinb.' xiii. 114–116; 'Nature,' xxxi. 428 (Abs.)
L. Respighi . .	Sulle osservazioni spettroscopiche del bordo e delle protuberanze solari fatte nel 1881 e 1884 al R. Osservatorio del Compidoglio. (Read March 1.)	'Atti R. Accad. d. Lincei, Rendiconti,' i. 174–181; 'Nature,' xxxii. 96 (Abs.)
C. Trépied . .	Sur le spectre et sur la formation de la queue de la comète d'Encke. (Read March 2.)	'C. R.' c. 616–618.
	Spectroscopic Results for the Motions of Stars in the Line of Sight obtained at the Royal Observatory, Greenwich, in the year 1884. No. VIII.	'Observatory,' xlv. 330–343.

ASTRONOMICAL APPLICATIONS, 1885.

Kleiber . .	Nos connaissances relativement à la composition des corps célestes. (Read at Russian Chem. Soc. March 7–19.)	'Bull. Soc. Chim.' xlv. 244 (Abs.); 'Chem. News,' liii. 214–215 (Abs.)
P. Tacchini . .	Sulla distribuzione in latitudine delle macchie, facole, protuberanze ed eruzioni solari osservate nel 1884 nel R. Osservatorio del Collegio Romano. (Read March 15.)	'Atti R. Accad. d. Lincei, Rendiconti,' i. 226–229; 'Nature,' xxxii. 120 (Abs.)
" .	Distribution en latitude des phénomènes solaires observés pendant l'année 1884. (March 11. Read March 30.)	'C. R.' c. 897–898; 'Nature,' xxxi. 547 (Abs.)
C. V. Zenger . .	La mesure des étoiles doubles au spectromètre. (Read March 30.)	'C. R.' c. 901–902.
E. W. Maunder .	The Motion of Stars in the Line of Sight.	'Observatory,' 1885, viii. 117–122, 162–170.
W. de W. Abney .	The Solar Spectrum from λ 7150 to λ 10,000. (Recd. May 6. Read May 21.)	'Phil. Trans.' clxxvii. 457–469; 'Proc. Roy. Soc.' xxxviii. 348 (Abs.); 'Beiblätter,' xii. 351–352 (Abs.)
C. Piazzi Smyth .	The Visual, Grating and Glass-Lens, Solar Spectrum, as observed in the year 1884. (Read June 1.)	'Proc. Roy. Soc. Edinb.' xiii. 174–175 (Abs.)
Tacchini . .	Observations des taches, des facules et des protubérances solaires, faites à l'observatoire du Collége romain pendant le premier trimestre de 1885. (Read June 2.)	'C. R.' c. 1371–1372.
W. Huggins . .	On the Corona of the Sun. (Bakerian Lecture. Recd. June 11. Read June 11.)	'Proc. Roy. Soc.' xxxix. 108–125.
E. L. Trouvelot .	Sur la structure intime de l'envelope solaire.	'Bull. Astron.' ii. 263–273, 364–373, 413–423; 'Nature,' xxxiii. 328 (Abs.); 'Beiblätter,' x. 571–573 (Abs.)
" .	Remarquables protubérances solaires diamétralement opposées. (Read July 6.)	'C. R.' ci. 50–52; 'L'Astronomie,' iv. 441–445.
P. Tacchini . .	Résumé des observations solaires, faites pendant le deuxième trimestre de l'année 1885. (July 24. Read July 27.)	'C. R.' ci. 303–304; 'Nature,' xxxii. 359 (Abs.)
E. L. Trouvelot .	Remarquable protubérance solaire. (Read Aug. 17.)	'C. R.' ci. 475–476; 'Beiblätter,' ix. 740 (Abs.)
D. Draper . .	On Solar Spectroscopy in the Infra Red. (Read Sept. 16.)	'Brit. Assoc. Report,' 1885, 936; 'Beiblätter,' xii. 193 (Abs.)
O. T. Sherman .	Spectrum of the Great Nebula in Orion.	'Science,' vi. 262, 336; 'Nature,' xxxiii. 42 (Abs.)
" .	The Spectrum of Nova Andromedæ. (Oct. 1.)	'Am. J.' [3] xxx. 378–380.

ASTRONOMICAL APPLICATIONS, 1885, 1886.

S. H. Saxby . .	The Spectroscope in the Alps. (Oct. 1885.)	'Observatory,' 1885, 357–362; 'Beiblätter,' x. 180–181 (Abs.)
J. S. Perry . .	The Outburst in Andromeda. (Nov. 11.)	'Monthly Not. Astr. Soc.' xlvi. 22.
E. W. Maunder .	Observations of the Spectrum of the New Star in the Great Nebula in Andromeda, made at the Royal Observatory, Greenwich. (Nov. 12.)	'Monthly Not. Astr. Soc.' xlvi. 19–21.
R. Copeland . .	On the Meteoric Shower of Nov. 27, 1885. (Nov. 30.)	'Monthly Not. Astr. Soc.' xlvi. 66–68.
O. T. Sherman .	Bright Lines in Stellar Spectra. (Nov. 1885.)	'Am. J.' [3], xxx. 475–477; 'Nature,' xxxiii. 161 (Abs.), 285 (Abs.); 'Beiblätter,' x. 500 (Abs.)
H. Homann . .	Bestimmung der Bewegung des Sonnensystems durch Spectral-Messungen. (Dec. 14.)	'Astron. Nachr.' cxiv. 25–26; 'Nature,' xxxiii. 450–451 (Abs.)
R. Copeland . .	Entdeckung eines neuen Sterns bei χ' Orionis. (Dec. 17.)	'Astron. Nachr.' cxiii. 167–168.
C. Wolf . . .	Sur l'étoile nouvelle d'Orion. (Read Dec. 28.)	'C. R.' ci. 1444–1445; 'Nature,' xxxiii. 235 (Abs.), 239 (Abs.)
H. Homann . .	Beiträge zur Untersuchung der Sternbewegungen und der Lichtbewegung durch Spectralmessungen. (Inaug. Dissert. Berlin, 1885.)	'Vierteljahrsschrift d. Astron. Ges.' xxi. 54–60 (Abs.); 'Beiblätter,' xi. 146–147 (Abs.)

1886.

C. Trépied . .	Sur la nouvelle étoile de la constellation d'Orion. (Read Jan. 4.)	'C. R.' cii. 40–41; 'Nature,' xxxiii. 264 (Abs.)
A. Riccò . .	The New Star near χ' Orionis. (Jan. 5.)	'Nature,' xxxiii. 269.
E. W. Maunder .	Observations of the Spectrum of Nova Orionis made at the Royal Observatory, Greenwich. (Jan. 6.)	'Monthly Not. Astr. Soc.' xlvi. 114–115.
R. Copeland . .	On a New Star in the Constellation of Orion. (Jan. 7.)	'Monthly Not. Astr. Soc.' xlvi. 109–114.
P. Tacchini . .	Résumé des observations solaires faites pendant la seconde moitié de l'année 1885. (Read Jan. 11.)	'C. R.' cii. 102–103; 'Nature,' xxxiii. 287 (Abs.)
,, . . .	Spectroscopic Results for the Motions of Stars in the Line of Sight, obtained at the Royal Observatory, Greenwich, in the year 1885. No. IX.	'Monthly Not. Astr. Soc.' xlvi. 126–135.
S. J. Perry . .	The Chromosphere in 1885 . .	'Observatory' 1886, 97–98; 'Nature,' xxxv. 446 (Abs.)
H. C. Vogel . .	Helle Linien in Sternspectren. (Feb. 6.)	'Astron. Nachr.' cxiii. 389, 390; 'Beiblätter,' x. 500 (Abs).

ASTRONOMICAL APPLICATIONS, 1886.

L. Thollon . .	Observations spectroscopiques de la nouvelle étoile, faites à Nice par MM. Perrotin et Thollon. (Read Feb. 15.)	'C. R.' cii. 356–358; 'Nature,' xxxiii. 406 (Abs.)
P. Tacchini . .	Résultats fournis par l'observation des protubérances solaires, pendant l'année 1885. (Feb. 12. Read Feb. 22.)	'C. R.' cii. 407–408; 'Nature,' xxxiii. 431 (Abs.)
C. V. Zenger . .	Études phosphorographiques pour la reproduction photographique du ciel. (Read Feb. 22.)	'C. R.' cii. 408–410; 'Nature,' xxxiii. 431 (Abs.)
H. C. Vogel . .	Die Bestimmung der Bewegung von Sternen im Visionsradius durch spectrographische Beobachtung. (Read Feb. 23.)	'Sitzungsb. Berl. Akad.' 1888, 397–401; 'Nature,' xl. 109 (Aqs.)
E. W. Maunder .	Note on some recently published Spectroscopic Observations.	'Monthly Not. Astr. Soc.' xlvi. 282–289.
A. C. Ranyard .	On the Connection between Photographic Action, the Brightness of the Luminous Object, and the Time of Exposure, as applied to Celestial Photography.	'Monthly Not. Astr. Soc. xlvi. 305–309.
A. Riccò . . .	Alcuni singolari fenomeni spettroscopistici.	'Mem. spettr. ital.' xv. 41–43; 'Il Nuovo Cimento,' xx. 32–36.
R. v. Kövesligethy .	Bestimmung der Bewegung des Sonnensystems durch Spectral-Messungen. (March 6.)	'Astron. Nach.' cxiv. 327–328; 'Nature,' xxxiv. 131 (Abs.)
J. G. Lohse . .	Observations of the New Star in Andromeda, made at Mr. Wigglesworth's Observatory with the 15·5-inch Cooke Refractor. (March 10.)	'Monthly Not. Astr. Soc.' xlvi. 299–302.
E. C. Pickering .	Stellar Photography. (March 10.)	'Mem. Amer. Acad.' xi. 179–226; 'Nature,' xxxv. 37 (Abs.); 'Beiblätter,' xi. 115–116 (Abs.)
C. Pritchard . .	The New Star in Orion photometrically and spectroscopically observed at the Oxford University Observatory. (March 11.)	'Monthly Not. Astr. Soc.' xlvi. 298.
P. Tacchini . .	Sur la distribution en latitude des phénomènes solaires pendant l'année 1885. (Read March 15.)	'C. R.' cii. 601–602; 'Nature,' xxxiii. 498 (Abs.)
E. C. Pickering .	The Photographic Study of Stellar Spectra.	'Science,' vii. 278; 'Beiblätter,' xi. 252–253 (Abs.)
A. Riccò . . .	Sur quelques phénomènes spectroscopiques singuliers. (Read April 12.)	'C. R.' cii. 851–853; 'Nature,' xxxiii. 599 (Abs.); 'Chem. News,' liii. 214 (Abs.); 'Beiblätter,' x. 401–402 (Abs.)
E. L. Trouvelot .	On the Protuberances Visible on the Spectrum with a Narrow Slit.	'Monthly Not. Astr. Soc.' xlvi. 331–333.

ASTRONOMICAL APPLICATIONS, 1886.

E. W. Maunder	Note on M. Trouvelot's Paper . .	'Monthly Not. Astr. Soc. xlvi. 334.
P. Tacchini . . .	Osservazioni solari e spettri di comete. (Read May 2.)	'Atti R. Accad. Lincei' [4] ii. 324–325.
C. Trépied . .	Sur le spectre de la comète Fabry. (Read May 3.)	'C. R.' cii. 1009–1010; 'Nature,' xxxiv. 40 (Abs.), 47 (Abs.)
J. N. Lockyer .	Further Discussion of the Sun-spot Spectra Observations made at Kensington. (Recd. May 5. Read May 6.)	'Proc. Roy. Soc.' xl. 347–362; 'Nature,' xxxiv. 251–257.
R. v. Kövesligethy .	Helligkeitsbestimmungen der Nova bei χ' Orionis mit Berücksichtigung der Farbe. (May 8.)	'Astron. Nachr.' cxiv. 371–376; 'Beiblätter, x. 571 (Abs.)
A. Cornu .	On the Distinction between Spectral Lines of Solar and Terrestrial Origin. (Read June 12.)	'Proc. Phys. Soc.' viii. 95–100; 'Phil. Mag.' [5] xxii. 458–463; 'J. Chem. Soc.' lii. 313 (Abs.); 'Am. J.' [3] xxxiii. 70 (Abs.)
L. Cruls . . .	Observations de la comète Fabry. (Read June 15.)	'C. R.' cii. 1364–1365; 'Nature,' xxxiv. 187 (Abs.); 'Chem. News,' liv. 12 (Abs.)
A. Riccò and A. Mascari.	Dimensioni e posizioni della protuberanze solari negli anni 1882, 1883, 1884, rilevate nel Regio Osservatorio di Palermo.	'Mem. spettr. ital.' xv. 99–126.
B. Hasselberg .	Sur une méthode propre à déterminer avec grande précision les longueurs d'onde des raies ultra-violettes du spectre solaire.	'Mem. spettr. ital.' xv. 127–133.
C. Fievez . .	Essai sur l'origine des raies de Fraunhofer, en rapport avec la constitution du soleil. (Read July 3.)	'Bull. Acad. Roy. Belg.' [3] xii. 25–32; 'Nature,' xxxiv. 562–563 (Abs.); 'Beiblätter,' xi. 94 (Abs.)
Tacchini . . .	Observations solaires du premier semestre de l'année 1886. (Read July 12.)	'C. R.' ciii. 120–121; 'Nature,' xxxv. 445–446 (Abs.)
O. T. Sherman .	Note on the Spectrum of Comet C, 1886.	'Am. J.' [3] xxxii. 157–159; 'Nature,' xxxiv. 402 (Abs.)
E. C. Pickering .	Draper Memorial Photographs of Stellar Spectra exhibiting Bright Lines.	'Nature,' xxxiv. 439–440.
O. T. Sherman .	Reply to certain Questions raised before the Royal Astronomical Society at the meeting on March 12, 1886, concerning the matter detailed in a Paper entitled 'Bright Lines in Stellar Spectra.'	'Monthly Not. Astr. Soc.' xlvii. 14–18.
A. Cortie . .	Bands observed in the Spectra of Sun-spots at Stonyhurst Observatory.	'Monthly Not. Astr. Soc.' xlvii. 19–22.

ASTRONOMICAL APPLICATIONS, 1886, 1887.

R. Copeland . .	On Hartwig's Nova Andromedæ. (Dec. 7.)	'Monthly Not. Astr. Soc.' xlvii. 49–61.
E. W. Maunder .	Mr. Sherman's Observations of Bright Lines in Stellar Spectra. (Dec. 10.)	'Monthly Not. Astr. Soc.' xlvii. 63–64.
Capt. Darwin .	Preliminary Account of the Observations of the Eclipse of the Sun at Grenada in August 1886. (Recd. Nov. 25. Read Dec. 16.)	'Proc. Roy. Soc.' xli. 469–470; 'Nature,' xxxv. 287.

1887.

G. M. Seabroke .	Spectroscopic Observations of the Motion of Stars in the Line of Sight, made at the Temple Observatory, Rugby.	'Monthly Notices,' xlvii. 93–100; 'Nature,' xxxv. 401–402 (Abs.)
	Spectroscopic Results for the Motion of Stars in the Line of Sight, obtained at the Royal Observatory, Greenwich, in the year 1886. No. X.	'Monthly Not. Astr. Soc.' xlvii. 101–108.
A. Riccò . .	Barnard's Comet at Perihelion. (Jan. 9.)	'Nature,' xxxv. 296.
R. Copeland . .	On the Variability of the Spectrum of γ Cassiopeiæ. (Jan. 12.)	'Monthly Not. Astr. Soc.' xlvii. 92–93.
J. N. Lockyer .	Further Discussion of Sun-spot Observations made at South Kensington. (Recd. Jan. 8. Read Jan. 20.)	'Proc. Roy. Soc.' xlii. 37–46.
P. Tacchini . .	Observations solaires du deuxième semestre 1886. (Read Jan. 24.)	'C. R.' civ. 216–217; 'Nature,' xxxv. 335 (Abs.), 445–446 (Abs.)
O. T. Sherman .	A short Study upon the Atmosphere of β Lyræ.	'Am. J.' [3] xxxiii. 126–129; 'Beiblätter,' xii. 50 (Abs.)
S. J. Perry . .	The Chromosphere in 1886.	'Observatory' 1887, 129; 'Nature,' xxxv. 446 (Abs.)
E. C. Pickering .	The Henry Draper Memorial. (March 1.)	'Nature,' xxxvi. 31–34.
P. Tacchini . .	Distribution en latitude des phénomènes solaires pendant l'année 1886. (March 3. Read March 7.)	'C. R.' civ. 671–673; 'Nature,' xxxv. 479 (Abs.)
A. Schuster . .	On the Total Solar Eclipse of Aug. 29, 1886. (Preliminary Account.) (Recd. March 3. Read March 17.)	'Proc. Roy. Soc.' xlii. 180–182; 'Nature,' xxxv. 549 (Abs.); 'Beiblätter,' xi. 797–798 (Abs.)
P. Tacchini . .	Observations solaires faites à Rome pendant le premier trimestre de l'année 1887. (Read April 18.)	'C. R.' civ. 1082; 'Nature,' xxxv. 624 (Abs.)
S. J. Perry . .	Report of the Observations of the Total Solar Eclipse of August 29, 1886, made at Carriacou. (Recd. April 5. Read May 5.)	'Proc. Roy. Soc.' xlii. 316–318.

ASTRONOMICAL APPLICATIONS, 1887, 1888.

Faye . . .	Note sur les premiers travaux de l'observatoire de Nice. (Read July 4.)	'C. R.' cv. 7–10; 'Nature,' xxxvi. 282 (Abs.)
Tacchini . .	Observations solaires faites à Rome pendant le premier et le deuxième trimestres de l'année 1887. (Read July 25.)	'C. R.' cv. 210–212; 'Nature,' xxxvi. 336 (Abs.)
G. Rayet . .	Éclipse partielle de Lune du 3 août 1887, observée à l'observatoire de Bordeaux. (Read Aug. 8.)	'C. R.' cv. 305–306; 'Nature,' xxxvi. 383 (Abs.)
J. Janssen . .	Note sur les travaux récents exécutés à l'observatoire de Meudon. (Read Aug. 16.)	'C. R.' cv. 325–328; 'Beiblätter,' xi. 821–822 (Abs.)
	Stars with remarkable Spectra.	'Nature,' xxxvi. 461–462.
E. L. Trouvelot .	Nouvelle éruption solaire. (Read Oct. 10)	'C. R.' cv. 610–612; 'Beiblätter,' xii. 103–104 (Abs.)
J. N. Lockyer .	Researches on the Spectra of Meteorites. A Report to the Solar Physics Committee. (Preliminary note Recd. Oct. 4. Addendum Recd. Nov. 15. Read Nov. 17.)	'Proc. Roy. Soc.' xliii. 117–156; 'Nature,' xxxvii. 55–61, 80–87; 'Beiblätter,' xii. 357 (Abs.); 'J. Chem. Soc.' liv. 638–639 (Abs.)
Thollon . . .	Spectroscopie Solaire . . .	'Annales de l'Obs. de Nice,' II. D2–D28; 'Nature,' xxxvi. 543 (Abs.)
Thollon and Gouy .	Sur la dèplacement des raies de sodium observé dans le spectre de la grande cométe de 1882.	'Annales de l'Obs. de Nice,' II. C64–C65.

1888.

R. von Kövesligethy	On Invisible Stars of Perceptibly Actinic Power. (Jan. 12.)	'Monthly Notices,' xlviii. 114–116; 'Beiblätter,' xii. 580–581 (Abs.)
P. Tacchini . .	Résumé des observations solaires, faites à Rome pendant le quatrième trimestre de 1887. (Jan. 23.)	'C. R.' cvi. 250–251; 'Nature,' xxxvii. 336 (Abs.), 423–424 (Abs.)
C. Trépied . .	Observations faites à l'observatoire d'Alger pendant l'éclipse totale de la Lune du 28 janvier 1888. (Read Feb. 6.)	'C. R.' cvi. 408–409.
H. H. Turner . .	Report of the Observations of the Total Solar Eclipse of August 29, 1886, made at Grenville, in the Island of Grenada. (Recd. Feb. 23. Read March 15.)	'Proc. Roy. Soc.' xliii. 428–430 (Abs.)
J. N. Lockyer .	Suggestions on the Classification of the various species of Heavenly Bodies. (Bakerian Lecture. Recd. March 21. Read April 12.)	'Proc. Roy. Soc.' xliv. 1–93; 'Nature,' xxxvii. 585–590, 606–609; xxxviii. 8–11, 31–35, 56–60; 'Beiblätter,' xii. 582–583 (Abs.)

ASTRONOMICAL APPLICATIONS, 1888, 1889.

P. Tacchini . .	Distribution en latitude des phénomènes solaires pendant l'année 1887. (Read April 30.)	'C. R.' cvi. 1285–1286; 'Nature,' xxxviii. 47 (Abs.)
" . .	Résumé des observations solaires faites à Rome pendant le premier trimestre de 1888. (Read April 30.)	'C. R.' cvi. 1286–1287; 'Nature,' xxxviii. 47–48 (Abs.)
" . .	Résumé des observations solaires faites à l'observatoire royal du Collége Romain pendant le deuxième trimestre de 1888. (Read Aug. 6.)	'C. R.' cvii. 387–388; 'Nature,' xxxviii. 408 (Abs.)
J. N. Lockyer .	The Maximum of Mira Ceti.	'Nature,' xxxviii. 621; 'Beiblätter,' xiii. 220–221 (Abs.)
" .	Notes on Meteorites.	'Nature,' xxxviii. 424–428, 456–458, 530–533, 556–559, 602–605, xxxix. 139–142, 233–236, 400–402.
" . .	Spectre maximum de Mira Ceti. (Read Nov. 19.)	'C. R.' cvii. 832–834; 'Beiblätter,' xiii. 220–221 (Abs.)
	1889.	
" . .	Suggestions on the Classification of the Various Species of Heavenly Bodies. (Appendix to the Bakerian Lecture. Recd. Nov. 22, 1888. Read Jan. 10, 1889.)	'Proc. Roy. Soc.' xlv. 157–262.
" . .	On the Spectrum of the Rings of Saturn. (Recd. and Read Feb. 7.)	'Proc. Roy. Soc.' xlv. 315–316; 'Beiblätter,' xiii. 509 (Abs.)
	Growth of our Knowledge of the Nebulæ.	'Nature,' xxxix. 353–354.
P. Tacchini . .	Résumé des observations solaires faites à l'observatoire royal du Collége Romain pendant le deuxième semestre 1888. (Read Feb. 18.)	'C. R.' cviii. 332–333; 'Nature,' xxxix. 432 (Abs.)
J. N. Lockyer .	On the Spectra of Meteor-Swarms. (Group III. Recd. Feb. 14. Read Feb. 28.)	'Proc. Roy. Soc.' xlv. 380–392.
	Photographic Map of the Normal Solar Spectrum (Second Series) made by Professor H. A. Rowland.	'Chem. News,' lix. 124–125.
A. F. . . .	The Spectrum of the Rings of Saturn.	'Nature,' xxxix. 564.
J. Fényi . .	Deux éruptions observées sur le Soleil en septembre 1888. (Read April 29.)	'C. R.' cviii. 889–891; 'Nature,' xl. 48 (Abs.), 64 (Abs.)
W. Huggins . .	Sur le spectre photographique de la grande nébuleuse d'Orion. (Read May 13.)	'C. R.' cviii. 984–986; 'Nature,' xl. 95–96 (Abs.); 'Beiblätter,' xiii. 509 (Abs.)

Astronomical Applications, 1889—Meteorological, 1883, 1884, 1885.

P. Tacchini . .	Distribution en latitude des phénomènes solaires pendant l'année 1888 et observations solaires du premier trimestre 1889. (Read May 27.)	'C. R.' cviii. 1094–1095; 'Nature,' xl. 144 (Abs.)
J. N. Lockyer .	Note sur le spectre d'Uranus. (Read June 3.)	'C. R.' cviii. 1149–1151.
„ . .	Notes on Meteorites. IX. . .	'Nature,' xl. 136–139.
W. Huggins , .	Sur le spectre photographique d'Uranus. (Read June 17.)	'C. R.' cviii. 1228–1229.
P. Tacchini . .	Résumé des observations solaires, faites à l'observatoire du Collége romain, pendant le deuxième trimestre de 1889. (Read July 22.)	'C. R.' cix. 131–132; 'Nature,' xl. 336 (Abs.)
J. Fenyi . .	Deux éruptions sur le Soleil. (Read July 22.)	'C. R.' cix. 132–133.
R. Wolf . . .	Sur les variations de latitude des taches solaires. (Read July 29.)	'C. R.' cix. 170; 'Nature,' xl. 383 (Abs.)

METEOROLOGICAL.

1883.

S. P. Langley .	Researches on Solar Heat and its Absorption by the Earth's Atmosphere. (Dec. 21.)	'Professional Papers U.S. Signal Service,' No. XV. 1884, pp. 242; 'Am. J.' [3] xxix. 258 (Notice)
C. S. Cook . .	On the use of the Spectroscope in Meteorology.	'Science,' ii. 488–491; 'Beiblätter,' ix. 332–333 (Abs.)

1884.

L. Thollon . .	Constitution et origine du groupe B du spectre solaire.	'Bull. Astron.' i. 223–230; 'Nature,' xxx. 520–521; 'Beiblätter,' viii. 824 (Abs.)
C. Piazzi Smyth .	Meteor-, Moon-, and Sun- Shine. (Sept. 6.)	'Nature,' xxx. 462–463.
„ . .	M. Thollon's Views of 'Great B' in the Solar Spectrum. (Sept. 27.)	'Nature,' xxx. 535–536; 'Beiblätter,' ix. 121 (Abs.)
L. Thollon . .	Constitution et origine du groupe B du spectre solaire.	'J. de Phys.' [2] iii. 421–427.

1885.

C. Michie Smith .	Iridescent Clouds. (Green Sun Spectrum.) (Jan. 1.)	'Nature,' xxxi. 338.
H. Deslandres . .	Relations entre le spectre ultraviolet de la vapeur d'eau et les bandes telluriques A, B, α du spectre solaire. (Read March 23.)	'C. R.' c. 854–857; 'Ber.' xviii. Referate, 253 (Abs.); 'J. Chem. Soc.' xlviii. 713–714 (Abs.); 'Beiblätter,' ix. 630–631 (Abs.)
S. P. Langley .	Sunlight and the Earth's Atmosphere. (Lecture, Royal Institution, April 17.)	'Nature,' xxxii. 17–20, 40–43.

METEOROLOGICAL, 1885, 1886, 1887, 1888.

J. Janssen	Analyse spectrale des éléments de l'atmosphère terrestre. (Read Oct. 5.)	'C. R.' ci. 649–651; 'Nature,' xxxii. 591 (Abs.); xxxiii. 89 (Abs.); 'Chem. News,' lii. 213 (Abs.); 'Ber.' xviii. Referate, 672 (Abs.); 'J. Chem. Soc.' l. 1 (Abs.); 'Beiblätter, ix. 789 (Abs.)
S. H. Saxby	The Spectroscope in the Alps. (Oct. 1885.)	'Observatory,' 1885, 357–362; 'Beiblätter,' x. 180–181 (Abs.)
L. Bell	Rainband Spectroscopy	'Am. J.' [3] xxx. 347–354; 'Beiblätter,' x. 181–182 (Abs.); 'Zeitschr. f. Instrumentenkunde,' vi. 144 (Abs.)
	1886.	
A. Cornu	Études des bandes telluriques α, B, et A du spectre solaire.	'Ann. Chim. et Phys.' [6] vii. 5–102; 'Beiblätter,' xi. 37 (Abs.)
E. B. Kirk	Aurora and Spectrum. (July 28.)	'Observatory,' 1886, 311-312; 'Beiblätter,' xi. 37 (Abs.)
C. Piazzi Smyth	The Silver-Blue Cloudlets again. (July 31.)	'Nature,' xxxiv. 311–312.
T. W. Backhouse	The Bright Clouds and the Aurora. (Aug. 18.)	'Nature,' xxxiv. 386–387.
	1887.	
W. de W. Abney	On the Atmospheric Transmission of Visual and Photographically Active Light.	'Monthly Not. Astr. Soc. xlvii. 260–265.
"	Transmission of Sunlight through the Earth's Atmosphere. (Recd. Feb. 17. Read March 10.)	'Phil. Trans.' clxxviii. A. 251–283; 'Proc. Roy. Soc.' xlii. 170–172 (Abs.); 'Beiblätter,' xii. 350–351 (Abs.)
A. Rankin	Rainband Observations at the Ben Nevis Observatory.	'Nature,' xxxv. 588–589.
S. P. Langley	Sunlight colours. (May 2.)	'Nature,' xxxvi. 76.
	1888.	
J. N. Lockyer	Notes on the Spectrum of the Aurora. (Recd. Jan. 9. Read Jan. 19.)	'Proc. Roy. Soc.' xliii. 320–322; 'Nature,' xxxvii. 358–359; 'Beiblätter,' xii. 663 (Abs.)
H. Hildebrandsson	The Aurora in Spitzbergen. (April 1888.)	'Nature,' xxxviii. 84–85.
J. Janssen	Sur le spectre tellurique dans les hautes stations, et en particulier sur le spectre de l'oxygène. (Read Oct. 29.)	'C. R.' cvii. 672–677; 'Nature,' xxxix. 41 (Abs.); 'Chem. News,' lviii. 244 (Abs.); 'Ber.' xxi. Referate, 821 (Abs.); 'Beiblätter,' xiii. 383 (Abs.)

METEOROLOGICAL, 1889—CHEMICAL RELATIONS, 1881, 1882, 1883.

A. Crova and — Houdaille.	Observations faites au sommet du mont Ventoux sur l'intensité calorifique de la radiation solaire. (Read Jan. 7.)	'C. R.' cviii. 35–39; 'Nature,' xxxix. 311 (Abs.)
E. Minary . .	Sur les étoiles filantes. (Read Feb. 18.)	'C. R.' cviii. 340.
Cornu . . .	Remarques.	'C. R.' cviii. 340–341; 'Nature,' xxxix. 432 (Abs.)
W. Huggins . .	On the Wave-length of the Principal Line in the Spectrum of the Aurora. (Recd. Feb. 19. Read March 7.)	'Proc. Roy. Soc.' xlv. 430–436; 'Chem. News,' lix. 161–163; 'Nature,' xl. 68–70; 'Beiblätter,' xiii. 507–508 (Abs.)
W. N. Hartley .	On the Limit of the Solar Spectrum, the Blue of the Sky, and the Fluorescence of Ozone.	'Nature,' xxxix. 474–477; 'Beiblätter,' xiii. 509–510 (Abs.)
J. Janssen . .	Sur l'origine tellurique des raies de l'oxygène dans le spectre solaire. (Read May 20.)	'C. R.' cviii. 1035–1037; 'Nature,' xl. 104; 'Chem. News,' lix. 281.

CHEMICAL RELATIONS.

1881.

L. Palmieri . .	Intorno ad alcune incompatibilità spettroscopiche. (Read Nov. 12.)	'Rend. Acc. di Napoli,' xx. 232–233; 'Beiblätter,' vi. 877 (Abs.); 'Zeitschr. anal. Chem.' xxii. 235–236 (Abs.); 'Chem. News,' xlvii. 247 (Abs.)
„ . .	Della riga dell' Helium apparsa in una recente sublimazione vesuviana. (Read Nov. 12.)	'Rend. Acc. di Napoli,' xx. 233; 'Beiblätter,' vi. 485 (Abs.)

1882.

C. H. Wolff . .	Einige neue Absorptionsspektren .	'Repert. anal. Chem.' ii. 55–56; 'Zeitschr. anal. Chem.' xxii. 96–97 (Abs.)
B. Brauner . .	Beitrag zur Chemie der Ceritmetalle. II. (Read June 15.)	'Sitzungsb. Wien. Akad.' lxxxvi. 168–185; 'Chem. Zeitung,' 1882, 959 (Abs.); 'Chem. News,' xlvi. 268 (Abs.)
G. D. Liveing and A. Dewar	Reversals of the Spectral Lines of Metals. (Read Aug. 28.)	'Brit. Assoc. Rep.' 1882, 495–496 (Abs.); 'Nature,' xxvi. 466 (Abs.); 'J. de Phys.' [2], ii. 434–435 (Abs.]

1883.

C. H. Wolff . .	Über die Dauer der spektralanalytischen Reaktion von Kohlenoxyd.	'Repert. anal. Chem.' iii. 82–84.
J. Reinke . .	Untersuchungen über die Einwirkung des Lichtes auf die Sauerstoffausscheidungen der Pflanzen.	'Bot. Zeitung,' 1883, 697–707, 713–723, 732–738; 'Ann. Agronomiques,' x. 38–40, 136–137; 'J. Chem. Soc.' xlvi. 1066 (Abs.)

CHEMICAL RELATIONS, 1883, 1884.

A. Dennig . .	Spectralanalytische Messungen der Sauerstoffzehrung der Gewebe in gesunden und kranken Zuständen.	'Zeitschr. f. Biol.' xix. 483–500; 'J. Chem. Soc.' xlvi. 1391–1392 (Abs.)
H. W. Vogel . .	Ueber das blauempfindliche Bromsilber.	'Phot. Mitth.' xix. 85; 'Beiblätter,' vii. 536–538 (Abs.)

1884.

T. W. Engelmann .	Untersuchungen über die quantitativen Beziehungen zwischen Absorption des Lichtes und Assimilation in Pflanzenzellen.	'Onderzoek. physiol. Lab. Utrecht,' [3] ix. 1–25; 'Bot. Zeitung,' 1884, 81–93, 97–105; 'Beiblätetr,' ix. 580–585 (Abs).
Petri . . .	Zum Verhalten der Aldehyde, des Traubenzuckers, der Peptone, der Eiweisskörper und des Acetons gegen Diazobenzolsulfonsäure. (March 10.)	'Zeitschr. physiol. Chem.' viii. 291–298; 'J. Chem. Soc.' xlvi. 1322–1323 (Abs.)
R. Nasini . .	Sulle costanti di rifrazione. (Read June 15.)	'Atti R. Accad. Lincei, Mem.' [3] xix. 195–218; 'Beiblätter,' ix. 322–324 (Abs.)
C. Auer v. Welsbach	Beiträge zur Spectralanalyse. (Read July 17.)	'Wien. Anz.' 1884, 160–161 (Abs.)
T. Poleck . .	Ueber die chemische Constitution des Safrols. (Recd. Aug. 13.)	'Ber.' xvii. 1940–1944; 'Beiblätter,' ix. 31 (Abs.)
H. Becquerel . .	Spectres d'émission infra-rouges des vapeurs métalliques. (Read Aug. 25.)	'C. R.' xcix. 374–376; 'Phil. Mag.' [5] xviii. 386–389; 'Am. J.' [3] xxviii. 459–461; 'Chem. News,' l. 127 (Abs.); 'J. Chem. Soc.' xlvi. 1237 (Abs.); 'Beiblätter,' viii. 819–820 (Abs.)
G. D. Liveing and J. Dewar.	On the Spectral Lines of the Metals developed by Exploding Gases.	'Phil. Mag.' [5] xviii. 161–173.
R. Thalén . .	Sur le spectre du fer obtenu à l'aide de l'arc électrique. (Read Sept. 26.)	'Upsala. Nova Acta Kongl. Vetensk. Soc.' [3] xii. 1–49; 'Nature,' xxxii. 253 (Abs.); 'Beiblätter,' ix. 520–521 (Abs.)
J. Reinke . .	Die Zerstörung von Chlorophylllösungen durch das Licht und eine neue Methode zur Erzeugung des Normalspectrums. (Oct. 1884.)	'Bot. Zeitung,' 1885, 65–70, 81–89, 97–101, 113–117, 129–137; 'Ann. Agronomiques,' xi. 231–236; 'J. Chem. Soc.' xlviii. 991–992 (Abs.)
Massanori Ogáta .	Über die Giftigkeit der schwefligen Säure. ('Arch. f. Hygicine,' ii. 223–245.)	'Chem. Centr.' 1884, 694–695 (Abs.); 'J. Chem. Soc.' xlviii. 577 (Abs.)
A. Jäderholm . .	Studien über Methämoglobin . .	'Zeitschr. f. Biol.' xx. 419–448; 'J. Chem. Soc.' xlviii. 407 (Abs.); 'Ber.' xviii. Referate, 480–481 (Abs.)

Chemical Relations, 1884, 1885.

G. Hoppe-Seyler .	Ueber die Wirkung des Phenylhydrazins auf den Organismus.	'Zeitschr. physiol. Chem.' ix. 34–39; 'J. Chem. Soc. xlviii. 574–575 (Abs.)
M. C. Traub and C. Hock.	Ueber ein Lakmoid. (Recd. Nov. 12. Read Nov. 24.)	'Ber.' xvii. 2615–2617.
S. Reformatsky .	Ueber einen aus Allyldiäthylcarbinol gewonnenen Kohlenwasserstoff: C_8H_{14}.	'J. pr. Chem.' [2] xxx. 217–224; 'Beiblätter,' ix. 114–115 (Abs.); 'J. Chem. Soc.' xlviii. 232–233 (Abs.)
J. M. Eder . .	Über das Verhalten der Haloïdverbindungen des Silbers gegen das Sonnenspectrum und die Steigerung der Empfindlichkeit derselben gegen einzelne Theile des Spectrums durch Farbstoffe und andere Substanzen. (Read Dec. 4.)	'Sitzungsb. Wien. Akad.' xc. II. 1097–1143; 'Monatsh.' vi. 1–47; 'J. Chem. Soc.' xlviii. 703–704 (Abs.); 'Chem. News,' li. 103–104 (Abs.); 'Ber.' xviii. Referate, 173–174 (Abs.)
W. N. Hartley .	The Absorption-spectra of the Alkaloids. (Recd. Nov. 19. Read Dec. 11.)	'Phil. Trans.' clxxvi. 471–521; 'Proc. Roy. Soc.' xxxviii. 1–4 (Abs.); 'J. Chem. Soc.' xlviii. 1174 (Abs.)
C. A. MacMunn .	On Myohaematin, an intrinsic muscle-pigment of Vertebrates and Invertebrates, on Histohaematin, and on the Spectrum of Suprarenal Bodies. (Read Dec. 13.)	'Proc. Physiol. Soc. J. Physiol.' v. xxiv.–xxxvi.; 'Nature,' xxxi. 326–327; 'Beiblätter,' ix. 422 (Abs.)
J. Parry . . .	The Spectroscopic Examination of the Vapours evolved on Heating Iron, &c., at Atmospheric Pressure.	'Chem. News,' l. 303–304; 'Beiblätter,' ix. 169 (Abs.)

1885.

M. Carey Lea .	On Combinations of Silver Chloride, Bromide, and Iodide with Coloring Matters.	'Am. J.' [3] xxix. 53–55; 'Chem. News,' li. 30–31; 'J. Chem. Soc.' xlviii. 350 (Abs.); 'Beiblätter,' ix. 336–337 (Abs.); 'Phil. Mag.' [5] xix. 229–231.
W. N. Hartley .	The Influence of Atomic Arrangement on the Physical Properties of Compounds.	'Phil. Mag.' [5] xix. 57–59; 'Beiblätter,' ix. 147 (Abs.)
J. H. Gladstone .	On the present state of our Knowledge of Refraction Equivalents.	'Am. J.' [3] xxix. 55–57.
P. T. Cleve . .	Om samariums föreningar. (Read Jan. 14.)	'Öfversigt K. Vetensk. Akad. Förhandlingar,' 1885, 15–20.
" . .	Nya undersökningar öfver didyms föreningar. (Read Jan. 14.)	'Öfversigt K. Vetensk. Akad. Förhandlingar,' 1885, 21–26.
R. Nasini . .	Sulla rifrazione atomica dello zolfo. (Read Jan. 18.)	'Atti R. Accad. d. Lincei, Rendiconti,' i. 74–78; 'Ber.' xviii. Referate, 254 (Abs.); 'Beiblätter, ix. 324–325 (Abs.)

CHEMICAL RELATIONS, 1885.

R. Nasini . .	Sul valore più elevato della rifrazione atomica del carbonio. (Read Jan. 18.)	'Atti R. Accad. d. Lincei, Rendiconti,' i. 78–82; 'Ber.' xviii. Referate, 255 (Abs.); 'Beiblätter,' ix 330–332 (Abs.)
G. J. Burch . .	Some Experiments on Flame.	'Nature,' xxxi. 272–275 'J. Chem. Soc.' xlviii. 466–467 (Abs.); 'Beiblätter,' ix. 422–423 (Abs.)
C. Kubierschky .	Ueber die Thiophosphorsäuren .	'J. pr. Chem.' xxxi. 93–111.
P. T. Cleve . .	Contributions to the Knowledge of Samarium. (Read Feb. 13.)	'Nova Acta R. Soc. Sci. Upsala,' [3] xiii. 39 pp.; 'Chem. News,' liii. 30–31, 45–47, 67–69, 80–82, 91–93, 100–102.
C. A. MacMunn .	Observations on some of the colouring matters of Bile and Urine, with especial reference to their origin; and on an easy method of procuring Haematin. (Read Feb. 14.)	'Proc. Physiol. Soc.' 1885, No. I. i.–iv.
E. Guignet . .	Extraction de la matière verte des feuilles; combinaisons définies formées par la chlorophyll. (Read Feb. 16.)	'C. R.' c. 434–437; 'Ber.' xviii. Referate, 196–197 (Abs.)
Lecoq de Boisbaudran.	Rectification à une Communication antérieure, relative au spectre du samarium. (Read March 2.)	'C. R.' c. 607; 'Chem. News,' li. 165 (Abs.); 'Beiblätter,' ix. 421 (Abs.)
W. N. Hartley .	The Absorption Spectra of the Alkaloids. Part II. (Recd. March 5. Read March 12.)	'Phil. Trans.' clxxvi. 471–521; 'Proc. Roy. Soc.' xxxviii. 191–193 (Abs.); 'Chem. News,' li. 135–136 (Abs.); 'Beiblätter,' ix. 519 (Abs.); 'J. Chem. Soc.' xlviii. 1174 (Abs.)
H. W. Vogel . .	Ueber die verschiedenen Bromsilbermodificationen und das Verhalten der Silberhaloidsalze gegen das Sonnenspektrum. (Recd. March 19. Read March 23.)	'Ber.' xviii. 861–865.
C. Timiriazeff .	Effet chimique et effet physiologique de la lumière sur la chlorophylle. (Read March 23.)	C. R.' c. 851–854; 'Ber.' xviii. Referate, 286 (Abs.); 'J. Chem. Soc.' xlviii. 714 (Abs.)
G. Krüss . .	Zur quantitativen Spectralanalyse. (Recd. March 30.)	'Ber.' xviii. 983–986; 'J. Chem. Soc.' xlviii. 835 (Abs.); 'Beiblätter,' ix. 421 (Abs.); 'Zeitschr. f. anal. Chem.' xxv. 210–211 (Abs.); 'Chem. News,' liv. 25 (Abs.)

Chemical Relations, 1885.

L. Bell . . .	Notes on the Absorption Spectrum of Nitrogen Peroxide.	'Am. Chem. J.' vii. 32–34 'Ber.' xviii. Referate 400 (Abs.); 'J. Chem. Soc.' xlviii. 949 (Abs.); 'Beiblätter,' ix. 578–579 (Abs.)
J. Bell . . .	Spectroscopic Determination of Lithium.	'Am. Chem. J.' vii. 35–36; 'J. Chem. Soc.' xlviii. 1012 (Abs.)
C. A. MacMunn .	Observations on some of the Colouring Matters of Bile and Urine, with especial reference to their origin; and on an easy Method of procuring Haematin from Blood.	'J. of Physiol.' vi. 22–39; 'J. Chem. Soc.' l. 638 (Abs.)
W. N. Hartley .	On Chlorophyll from the Deep Sea. (Read April 6.)	'Proc. Roy. Soc. Edinb.' xiii. 130–136; 'J. Chem. Soc.' l. 367 (Abs.)
C. A. MacMunn .	Further Observations on Enterochlorophyll and Allied Pigments. (Recd. April 21. Read April 30.)	'Phil. Trans.' clxxvii. 235–266; 'Proc. Roy. Soc.' xxxviii. 319–322 (Abs.); 'Nature,' xxxii. 69 (Abs.); 'J. Chem. Soc.' xlviii. 1242 (Abs.)
J. M. Eder . .	Das Verhalten der Silberhaloïdsalze gegen das Sonnenspectrum und die orthochromatische Photographie. (April 26. Recd. April 30.)	'Ber.' xviii. 1265–1267.
J. B. Messerschmit	Spectralphctometrische Untersuchungen einiger photographischer Sensibilisatoren. (April 1885.)	'Ann. Phys. u. Chem.' N.F. xxv. 655–673; 'Nature,' xxxii. 519 (Abs.); 'J. Chem. Soc.' xlviii. 1097–1098 (Abs.)
E. Schunk . .	Contributions to the Chemistry of Chlorophyll. (Recd. April 30. Read May 7.)	'Proc. Roy. Soc.' xxxviii. 336–340 (Abs.); 'Nature,' xxxii. 117–118 (Abs.); 'Ber.' xviii. Referate, 567 (Abs.); 'J. Chem. Soc.' xlviii. 1241–1242 (Abs.)
W. N. Hartley .	Researches on the Relation between the Molecular Structure of Carbon Compounds and their Absorption Spectra. Part VII. (Read May 7.)	'J. Chem. Soc.' xlvii. 685–757; 'Nature,' xxxii. 93–94 (Abs.); 'Chem. News,' li. 235 (Abs.); 'Ber.' xviii. Referate, 592–593 (Abs.); 'Am. J.' [3] xxxi. 58–59 (Abs.); 'Beiblätter,' x. 402–404 (Abs.)
E. Linnemann .	Verarbeitung und qualitative Zusammensetzung des Zirkons. (Read May 7.)	'Sitzungsb. Wien. Akad.' xci. II. 1019–1031; 'Monatsh.' vi. 335–347; 'Chem. News,' lii. 233–235, 240–242.
G. Krüss . .	Beziehungen zwischen der Zusammensetzung und den Absorptionsspectren organischer Verbindungen. II. (Recd. May 20.)	'Ber.' xviii. 1426–1433; 'J. Chem. Soc.' xlviii. 949 (Abs.)

CHEMICAL RELATIONS, 1885.

J. Kanonnikoff .	Untersuchungen über das Lichtbrechungsvermögen chemischer Verbindungen.	'J. pr. Chem.' [2] xxxi. 321–363; 'Chem. News,' lii. 94 (Abs.); 'Ber.' xviii. Referate, 425 (Abs.)
W. Crookes . .	Sur la spectroscopie par la matière radiante. (Read June 2.)	'C. R.' c. 1380–1382; 'Chem. News,' lii. 23 (Abs.); 'Beiblätter,' ix. 579–580 (Abs.)
G. Krüss . .	Titerstellung der Lösungen von Kaliumpermanganat. (Recd. June 10.)	'Ber.' xviii. 1580–1585; 'Beiblätter,' ix. 740 (Abs.)
W. Crookes . .	Sur la spectroscopie par la matière radiante. Extinction mutuelle des spectres d'yttrium et de samarium. (Read June 15.)	'C. R.' c. 1495–1497; 'Chem. News,' lii. 46–47 (Abs.); 'J. Chem. Soc.' xlviii. 1025–1026 (Abs.); 'Ber.' xviii. Referate, 491 (Abs.); 'Beiblätter,' x. 171–172 (Abs.)
,, . . .	On Radiant Matter Spectroscopy. Part II. Samarium. (Recd. May 21. Read June 18.)	'Phil. Trans.' clxxvi. 691–723; 'Proc. Roy. Soc.' xxxviii. 414–422 (Abs.); 'Nature,' xxxii. 283–285 (Abs.); 'Chem. News,' liv. 28–31, 40–43, 54–57, 63–66, 76–78; 'Ber.' xix. Referate, 736–738 (Abs.)
C. Auer v. Welsbach	Die Zerlegung des Didyms in seine Elemente. (Read June 18.)	'Sitzungsb. Wien. Akad.' xcii. II. 317–331; 'Monatshefte,' vi. 477–491; 'Wien. Anz.' 1885, 137–138(Abs.); 'Chem. News,' lii. 49 (Abs.); 'J. Chem. Soc.' xlviii. 1113 (Abs.); 'Ber.' xviii. Referate, 605 (Abs.); 'Beiblätter,' ix. 645–646 (Abs.)
J. M. Eder . .	Untersuchungen über die chemischen Wirkungen des Lichtes. (Read June 18.)	'Sitzungsb. Wien Akad.' xcii. II. 340–350; 'Wien. Anz.' 1885, 133–134 (Abs.); 'Monatshefte,' vi. 495–505; 'Beiblätter,' x. 31–32 (Abs.)
C. Girard and Pabst	Sur les spectres d'absorption de quelques matières colorantes. (Read July 13.)	'C. R.' ci. 157–160; 'Chem. News,' lii. 54–55 (Abs.); 'J. Chem. Soc.' xlviii. 1098 (Abs.); 'J. de Pharm.' [5] xii. 306–309.
B. Lachowicz and M. Nencki.	Ueber das Parahämoglobin. (July 1885.)	'Ber.' xviii. 2126–2131.
M. Nencki . .	Ueber das Parahämoglobin. (Aug. 1885.)	'Archiv. f. exp. Pathol.' xx. 332–346; 'Ber.' xix. Referate, 605–606 (Abs.)
S. v. Kostanecki and S. Niementowski.	Ueber die isomeren Dioxydimethylanthrachinone. (Recd. Aug. 5.)	'Ber.' xviii. 2138–2141.

CHEMICAL RELATIONS, 1885.

J. H. Gladstone .	The Value of the Refraction Goniometer in Chemical Work. (Brit. Assoc. 1885.)	'Nature,' xxxiii. 352–353.
H. W. Vogel . .	Ueber den Zusammenhang zwischen Absorption der Farbstoffe und deren sensibilisirender Wirkung auf Bromsilber. (Sept. 1885.)	'Ann. Phys. u. Chem.' N.F. xxvi. 527–530; 'J. Chem. Soc.' l. 585 (Abs.)
Lecoq de Boisbaudran.	Sur la fluorescence des terres rares. (Read Sept. 7 and 14.)	'C. R.' ci. 552–555, 588–592; 'Chem. News,' lii. 290–291, 299–300; 'J. Chem. Soc.' xlviii. 1174–1175 (Abs.); 'Beiblätter,' x. 172–173 (Abs.)
N. Pringsheim .	Ueber die Sauerstoffabgabe der Pflanzen im Mikrospectrum. (Sept. 19.)	'Pflüger's Archiv,' xxxviii. 142–153; 'Ber.' xix. Referate, 619–620 (Abs.)
J. Janssen . .	Analyse spectrale des éléments de l'atmosphère terrestre. (Read Oct. 5.)	'C. R.' ci. 649–651; 'Nature,' xxxii. 591 (Abs.); xxxiii. 89 (Abs.); 'Chem. News,' lii. 213 (Abs.); 'Ber.' xviii. Referate, 672 (Abs.); 'J. Chem. Soc.' l. 1 (Abs.); 'Beiblätter,' ix. 789 (Abs.)
W. D. Halliburton .	On the Blood of Decapod Crustacea.	'J. of Physiol.' vi. 300–335; 'J. Chem. Soc.' l. 639–640 (Abs.)
K. B. Hofmann .	Beitrag zur spectralanalytischen Bestimmung des Lithiums. (Recd. Nov. 5. Read Nov. 9.)	'Ber.' xviii. 2897–2898.
D. Axenfeld . .	Die Wirkung der Halogene auf das Hæmin. (Nov. 21.)	'Centralbl. f. d. med. Wissensch.' 1885, 833–835; 'Ber.' xix. Referate, 578 (Abs.)
C. A. MacMunn .	Researches on Myohæmatin and the Histohæmatins. (Recd. Oct. 19. Read Nov. 26.)	'Phil. Trans.' clxxvii. 267–298; 'Proc. Roy. Soc.' xxxix. 248–252 (Abs.); 'J. Chem. Soc.' l. 568 (Abs.); 'Ber.' xx. Referate, 333–334 (Abs.)
J. J. Hood . .	'Didymium.'	'Chem. News,' lii. 271–272.
J. Kanonnikoff .	Untersuchungen über das Lichtbrechungsvermögen chemischer Verbindungen. (II. Abhandlung.)	'J. pr. Chem.' N.F. xxxii. 497–523; 'Ber.' xix. Referate, 4 (Abs.); 'J. Chem. Soc.' l. 335–336 (Abs.)
G. Henslow . .	A Contribution to the Study of the Relative Effects of Different Parts of the Solar Spectrum on the Transpiration of Plants. (Read Dec. 3.)	'J. Linnean Soc.' xxii. 81–98; 'Nature,' xxxiii. 165 (Abs.)

CHEMICAL RELATIONS, 1885, 1886.

J. M. Eder . .	Über die Wirkung verschiedener Farbstoffe auf das Verhalten des Bromsilbers gegen das Sonnenspectrum und spectroskopische Messungen über den Zusammenhang der Absorption und photographische Sensibilisirung. (Read Dec. 3.)	'Sitzungsb. Wien. Akad.' xcii. II. 1346–1372; 'Monatshefte,' vi. 927–953; 'Wien. Anz.' 1885, 242–243 (Abs.); 'Ber.' xix. Referate, 132 (Abs.); 'J. Chem. Soc.' l. 405–406 (Abs.); 'Beiblätter,' x. 228–230 (Abs.)
N. Egoroff . .	Spectre d'absorption de l'oxygène. (Read Dec. 7.)	'C. R.' ci. 1143–1145; 'Nature,' xxxiii. 168 (Abs.); 'Ber.' xix. Referate, 6 (Abs.); 'J. Chem. Soc.' l. 189 (Abs.); 'Beiblätter,' x. 357 (Abs.)
H. Deslandres .	Spectre de bandes de l'azote; son origine. (Read Dec. 14.)	'C. R.' ci. 1256–1260; 'Nature,' xxxiii. 192 (Abs.); 'Chem. News,' liii. 11 (Abs.); 'J. Chem. Soc.' l. 189 (Abs.); 'Beiblätter,' x. 356–357 (Abs.)
J. M. Eder . .	Photometrische Versuche über die sensibilisirende Wirkung von Farbstoffen auf Chlorsilber und Bromsilber bei verschiedenen Lichtquellen und Notizen zur orthochromatischen Photographie. (Read Dec. 17.)	'Sitzungsb. Wien. Akad.' xciii. 4–11; 'Monatsh. f. Chem.' vii. 1–8; 'Ber.' xix. Referate, 235–236 (Abs.); 'J. Chem. Soc.' l. 497 (Abs.)
	1886.	
G. Bonnier and L. Mangin.	L'action chlorophyllienne dans l'obscurité ultra-violette. (Read Jan. 11.)	'C. R.' cii. 123–126; 'Ber.' xix. Referate, 107 (Abs.); 'Beiblätter,' x. 501 (Abs.)
N. Pringsheim .	Über die Sauerstoffabgabe der Pflanzen im Mikrospectrum. (Read Feb. 14, 1884, and Jan. 14, 1886.)	'Sitzungsb. Berl. Akad.' 1886, 137–175; 'Beiblätter,' x. 767–769 (Abs.)
Lecoq de Boisbaudran.	Sur un spectre électrique particulier aux terres rares du groupe terbique. (Read Jan. 18.)	'C. R.' cii. 153–155; 'Chem. News,' liii. 63; 'J. Chem. Soc.' l. 293 (Abs.); 'Ber.' xix. Referate, 132–133 (Abs.)
W. Crookes . .	On Radiant Matter Spectroscopy; Note on the Spectra of Erbia. (Recd. Jan. 7. Read Jan. 21.)	'Proc. Roy. Soc.' xl. 77–79; 'Nature,' xxxiii. 474; 'Chem. News,' liii. 75–76; 'J. Chem. Soc.' l. 749 (Abs.)
M. Nencki and N. Sieber.	Venöse Hämoglobinkrystalle. (Read Jan. 27.)	'Ber.' xix. 128–130; 'J. Chem. Soc.' l. 374 (Abs.); 'Chem. News,' liii. 227 (Abs.)
— . .	Berichtigung. (Read Feb. 22.) .	'Ber.' xix. 410.

CHEMICAL RELATIONS, 1886.

C. Liebermann .	Ueber Azoopiansäure und einen neuen Indigoabkömmling. (Read Feb. 8.)	'Ber.' xix. 351–354.
G. Hüfner . .	Wirkt ausgekochtes, völlig sauerstofffreies, Wasser zersetzend auf Hämoglobin? (Recd. Feb. 12.)	'Zeitschr. f. physiol. Chem.' x. 218–226; 'Ber.' xix. Referate, 768 (Abs.)
L. Macchiati . .	La Xantofillidrina. (Feb. 15.) .	'Gazz. chim. ital.' xvi. 231–234; 'Ber.' xix. Referate, 887 (Abs.)
Lecoq de Boisbaudran.	Sur l'équivalent des terbines. (Read Feb. 22.)	'C. R.' cii. 395–398; 'Chem. News,' liii. 121–122; 'J. Chem. Soc.' l. 424–425 (Abs.), 507 (Abs.)
W. Crookes . .	On Radiant Matter Spectroscopy; Note on the Earth Yα. (Recd. Feb. 18. Read Feb. 25.)	'Proc. Roy. Soc.' xl. 236–237; 'Chem. News,' liii. 133.
A. Cornu . .	Sur les raies spectrales spontanément renversables et l'analogie de leurs lois de répartition et d'intensité avec celles des raies de l'hydrogène.	'J. de Phys.' [2] v. 93–100; 'Nature,' xxxiv. 105–106 (Abs.)
T. W. Engelmann .	Zur Technik und Kritik der Bacterienmethode.	'Pflüger's Archiv,' xxxviii. 386–400; 'Ber.' xix. Referate, 620 (Abs.)
W. Crookes . .	Sur les spectres de l'erbine. (Read March 1.)	'C. R.' cii. 506–507; 'Nature,' xxxiii. 450 (Abs.); 'Ber.' xix. Referate, 234 (Abs.); 'Beiblätter,' xi. 93 (Abs.)
A. Recoura . .	Sur les états isomériques du sesquichlorure de chrome, sesquichlorure vert. (Read March 1.)	'C. R.' cii. 515–518; 'Ber.' xix. Referate, 233 (Abs.); 'J. Chem. Soc.' l. 508–510 (Abs.)
" . .	Sur les états isomériques du sesquichlorure de chrome. Chlorure hydraté gris. Chlorure anhydre. (Read March 8.)	'C. R.' cii. 548–551; 'Ber.' xix. Referate, 233 (Abs.); 'J. Chem. Soc.' l. 508–510 (Abs.)
W. Crookes . .	Sur la terre Yα. (Read March 15.)	'C. R.' cii. 646–647; 'Nature,' xxxiii. 525; 'Ber.' xix. Referate, 234 (Abs.); 'J. Chem. Soc.' l. 506–507 (Abs.); 'Am. J.' [3] xxxii. 76 (Abs.)
Lecoq de Boisbaudran.	Sur la mosandrine de Lawrence Smith. (Read March 15.)	'C. R.' cii. 647–648; 'Chem. News,' liii. 168 (Abs.); 'Ber.' xix. Referate, 234–235 (Abs.); 'J. Chem. Soc.' l. 507 (Abs.)
W. de W. Abney .	Comparative Effects of different parts of the Spectrum on Silver Salts. (Recd. March 2. Read March 18.)	'Proc. Roy. Soc.' xl. 251–254; 'J. Chem. Soc.' l. 749 (Abs.)

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C. Timiriazeff	La chlorophylle et la réduction de l'acide carbonique par les végétaux. (Read March 22.)	'C. R.' cii. 686–689; 'Chem. News,' liii. 180 (Abs.); 'Ber.' xix. Referate, 355 (Abs.)
T. S. Humpidge	The Spectra of Erbia. (March 22.)	'Chem. News,' liii. 154–155.
E. Noah	Pentaoxyanthrachinon und Anthrachryson. (Read March 22.)	'Ber.' xix. 751–755.
E. L. Kahn	Ueber Dimethylanthrachryson. (Read March 22.)	'Ber.' xix. 755–757; 'J. Chem. Soc.' l. 556 (Abs.)
J. F. Boutet	Analyse des eaux minérales de Saint-Nectaire (Puy-de-Dome) et travaux d'analyse spectrale.	'Ann. Chim. et Phys.' [6] vii. 536–561.
"	Analyse des eaux potables de Royat (Puy-de-Dome).	'Ann. Chim. et. Phys.' [6] vii. 562–570.
J. M. Eder	Ueber die Wirkung verschiedener Farbstoffe auf das Verhalten des Bromsilbers gegen das Sonnenspectrum. (Read April 1.)	'Wien. Anz.' 1886, 68.
W. N. Hartley	The Spectra of Erbia	'Chem. News,' liii. 179.
Lecoq de Boisbaudran.	Les fluorescences Zα et Zβ appartiennent-elles à des terres différentes? (Read April 19.)	'C. R.' cii. 899–902; 'Nature,' xxxiii. 623 (Abs.) 'Chem. News,' liii. 217–218; 'Ber.' xix. Referate, 333 (Abs.); 'J. Chem. Soc.' l. 666–667 (Abs.)
"	Le Yα de M. de Marignac est définitivement nommé *gadolinium*. (Read April 19.)	'C. R.' cii. 902; 'Chem. News,' liii. 225 (Abs.); 'Am. J.' [3] xxxii. 406 (Abs.)
"	L'holmine (ou terre X de M. Soret) contient au moins deux radicaux métalliques. (Read May 3.)	'C. R.' cii. 1003–1004; 'Chem. News,' liii. 265; 'Ber.' xix. Referate, 388 (Abs.); 'J. Chem. Soc.' l. 667 (Abs.): 'Am. J.' [3] xxxii. 406 (Abs.)
"	Sur le dysprosium. (Read May 3.)	'C. R.' cii. 1005–1006; 'Chem. News,' liii. 265–266; 'Ber.' xix. Referate, 388 (Abs.); 'J. Chem. Soc.' l. 667 (Abs.); 'Am. J.' [3] xxxii. 406 (Abs).
H. Gorceix	Sur la 'xénotime' de Minas Geraes (Brésil). (Read May 3.)	'C. R.' cii. 1024–1026; 'J. Chem. Soc.' l. 676 (Abs.)
E. Linnemann	Austrium, ein neues metallisches Element. (Read May 6.)	'Sitzungsb. Wien. Akad.' xciii. II. 662–664; 'Monatsh. f. Chem.' vii. 121–123; 'Wien. Anz.' 1886. 87–88 (Abs.); 'Ber.' xix. Referate, 431 (Abs.); 'J. Chem. Soc.' l. 773 (Abs.); 'Beiblätter,' x. 542 (Abs.); 'Am. J.' [3] xxxii. 406 (Abs.)

CHEMICAL RELATIONS, 1886.

C. Timiriazeff.	Chlorophyll	'Nature,' xxxiv. 52.
L. Bell	The Ultra-violet Spectrum of Cadmium.	'Am. J.' [3] xxxi. 426–432; 'Nature,' xxxiv. 208 (Abs.); 'J. Chem. Soc.' l. 957–958 (Abs.); 'Beiblätter,' x. 699 (Abs.)
Lecoq de Boisbaudran.	Sur le poids atomique et sur le spectre du germanium. (Read June 7.)	'C. R.' cii. 1291–1295; 'Nature,' xxxiv. 163 (Abs.); 'Chem. News,' liv. 4–5 (Abs.); 'Ber.' xix. Referate, 479–480 (Abs.); 'J. Chem. Soc.' l. 768 (Abs.); 'Beiblätter,' x. 569 (Abs.)
W. Crookes	On some new Elements in Gadolinite and Samarskite, detected spectroscopically. (Recd. June 9. Read June 10.)	'Proc. Roy. Soc.' xl. 502–509; 'Nature,' xxxiv. 160–162; 'Chem. News,' liv. 13–15; 'Ber.' xix. Referate, 651–652 (Abs.); 'J. Chem. Soc.' lii. 334–335 (Abs.)
J. M. Eder	Über die Wirkung verschiedener Farbstoffe auf das Verhalten des Bromsilbers gegen das Sonnenspectrum. (Read June 10.)	'Situngsb. Wien. Akad.' xciv. II. 75–94; 'Monatsh.' vii. 331–350; 'J. Chem. Soc.' l. 958–959 (Abs.); 'Beiblätter,' x. 701–702 (Abs.)
J. Janssen	Sur les spectres d'absorption de l'oxygène. (Read June 15.)	'C. R.' cii. 1352–1353; 'Nature,' xxxiv. 176 (Abs.); 'Chem. News,' liv. 19 (Abs.); 'Ber.' xix. Referate, 479 (Abs.); 'J. Chem. Soc.' l. 749 (Abs.); 'Beiblätter,' xi. 93–94 (Abs.)
J. H. Gladstone	On Essential Oils. Part III. Their Specific Refractive and Dispersive Energy. (Read June 17.)	'J. Chem. Soc.' xlix. 609–623; 'Ber.' xix. Referate, 807–808 (Abs.); 'Beiblätter,' xi. 771 (Abs.)
G. Kobb	Ueber das Spectrum des Germaniums. (June 19.)	'Ann. Phys. u. Chem.' N.F. xxix. 670–671; 'J. Chem. Soc.' lii. 313–314 (Abs.); 'Am. J.' [3] xxxiii. 151 (Abs.)
R. Nasini and A. Scala.	Sulla rifrazione molecolare dei solfocianati, degli isosolfocianati e del tiofene. (Read June 20.)	'Rend. R. Acc. Lincei,' [4] ii. 1st semestre, 617–623; 'Gazz. chim. ital.' xvii. 66–72; 'Beiblätter,' x. 695–698 (Abs.); 'Ber.' xx. Referate, 193–194 (Abs.); 'J. Chem. Soc.' lii. 754 (Abs.)

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R. Nasini and A. Scala.	Sulla rifrazione moleculare di alcuni derivati del solfuro di carbonio. (Read June 20.)	'Rend. R. Acc. Lincei,' [4] ii. 1st semestre, 623–628; 'Gazz. chim. ital.' xvii. 72–78; 'Beiblätter,' x. 695–698 (Abs.); 'Ber.' xx. Referate, 194–195 (Abs.); 'J. Chem. Soc.' lii. 753–754 (Abs.)
Lecoq de Boisbaudran.	Sur l'annonce de la découverte d'un nouveau métal, l'*austrium*. (Read June 21.)	'C. R.' cii. 1436; 'Nature,' xxxiv. 211 (Abs.); 'Chem. News,' liv. 23 (Abs.); 'Beiblätter,' x. 542 (Abs.); 'Ber.' xix. Referate, 650 (Abs.)
W. Crookes . .	Sur la présence d'un nouvel élément dans la samarskite. (Read June 21.)	'C. R.' cii. 1464–1466; 'Nature,' xxxiv. 212 (Abs.)
Lecoq de Boisbaudran.	Sur la fluorescence anciennement attribuée à l'yttria. (Read June 28.)	'C. R.' cii. 1536–1539; 'Chem. News,' liv. 15–16; 'Nature,' xxxiv. 235 (Abs.); 'J. Chem. Soc.' l. 838 (Abs.); 'Ber.' xix. Referate, 649–650 (Abs.)
E. Demarçay . .	Sur les spectres du didyme et du samarium. (Read June 28.)	'C. R.' cii. 1551–1552; 'Chem. News,' liv. 36–37 (Abs.); 'J. Chem. Soc.' l. 837–838 (Abs.); 'Ber.' xix. Referate, 650–651 (Abs.); 'Beiblätter,' x. 622–623 (Abs.)
J. W. Brühl . .	Untersuchungen über die Molekularrefraction organischer flüssiger Körper von grossem Farbenzerstreuungsvermögen. (June 1886.)	'Ann. der Chem.' ccxxxv. 1–106; 'Chem. News,' liv. 213–214 (Abs.); 'J. Chem. Soc.' lii. 191–195 (Abs.); 'Beiblätter,' xi. 240–244 (Abs.)
P. Sabatier . .	Spectres d'absorption des chromates alcalins et de l'acide chromique. (Read July 5.)	'C. R.' ciii. 49–52; 'Chem. News,' liv. 44; 'J. Chem. Soc.' l. 838–839 (Abs.); 'Ber.' xix. Referate, 649 (Abs.); 'Beiblätter,' xi. 223 (Abs.)
J. M. Eder . .	Über einige geeignete praktische Methoden zur Photographie des Spectrums in seinen verschiedenen Bezirken mit sensibilisirten Bromsilberplatten. (Read July 8.)	'Sitzungsb. Wien. Akad.' xciv. II. 378–403; 'Monatshefte,' vii. 429–454; 'Ber.' xix. Referate, 743 (Abs.); 'Beiblätter,' xi. 39–40 (Abs.); 'J. Chem. Soc.' lii. 93 (Abs.)
Lecoq de Boisbaudran.	Identité d'origine de la fluorescence $Z\beta$ par renversement et des bandes obtenues dans le vide par M. Crookes. (Read July 12.)	'C. R.' ciii. 113–117; 'Nature,' xxxiv. 284 (Abs.); 'J. Chem. Soc.' l. 958 (Abs.); 'Ber.' xix. Referate, 650 (Abs.)
K. Heumann and T. Heidlberg.	Ueber den Einfluss substituirender Elemente und Radicale auf die Nuance einiger Farbstoffe. I. (Recd. July 9. Read July 12.)	'Ber.' xix. 1989–1993.

Chemical Relations, 1886.

W. Crookes . .	Note on the Absorption Spectrum of Didymium.	'Chem. News,' liv. 27; 'Nature,' xxxiv. 266; 'Ber.' xix. Referate, 652 (Abs.)
" . .	What is Yttria?	'Chem. News,' liv. 39–40; 'J. Chem. Soc.' l. 853 (Abs.)
E. L. Cahn . .	Ueber Methylanthragallole. (Recd. Aug. 2.)	'Ber.' xix. 2333–2336; 'J. Chem. Soc.' lii. 57 (Abs.)
E. Noah . . .	Ueber zwei neue Tetraoxyanthrachinone. (Recd. Aug. 2.)	'Ber.' xix. 2337–2340.
H. Deslandres .	Spectre du pôle négatif de l'azote. Loi générale de répartition des raies dans les spectres de bandes. (Read Aug. 9.)	'C. R.' ciii. 375–379; 'Chem. News,' liv. 100; 'Nature,' xxxiv. 380 (Abs.); 'J. Chem. Soc.' l. 957 (Abs.); 'Beiblätter,' xi. 36 (Abs.)
C. Liebermann and S. Kleemann.	Ueber Opiansäurederivate. (Recd. Aug. 11.)	'Ber.' xix. 2287–2299.
C. Liebermann and St. v. Kostanecki.	Ueber die Spektra der methylirten Oxyanthrachinone. (Recd. Aug. 13.)	'Ber.' xix. 2327–2332.
Lecoq de Boisbaudran.	Sur le poids atomique du germanium. (Read Aug. 30.)	'C. R.' ciii. 452–453; 'Nature,' xxxiv. 463 (Abs.); 'Beiblätter,' x. 569 (Abs.); 'J. Chem. Soc.' lii. 15 (Abs.)
W. Crookes . .	On the Fractionation of Yttria. (Brit. Assoc., Sept. 1886.)	'Chem. News,' liv. 155–158; 'Nature,' xxxiv. 584–587; 'Ber.' xix. Referate, 738 (Abs.)
J. H. Gladstone .	The Essential Oils: a Study in Optical Chemistry. (Brit. Assoc., Sept. 1886.)	'Chem. News,' liv. 323.
W. J. Russell and W. Lapraik.	Absorption Spectra of Uranium Salts. (Brit. Assoc.)	'Nature,' xxxiv. 510 (Abs.); 'Beiblätter,' xi. 822 (Abs.)
Lecoq de Boisbaudran.	Fluorescence des composés du manganèse soumis à l'influence électrique dans le vide. (Read Sept. 6.)	'C. R.' ciii. 468–471; 'Nature,' xxxiv. 491 (Abs.); 'Chem. News,' liv. 165 (Abs.); 'Ber.' xix. Referate, 738–739 (Abs.); 'Beiblätter,' x. 702–703 (Abs.), xi. 37–38 (Abs.); 'J. Chem. Soc.' lii. 3–4 (Abs.); 'Am. J.' [3] xxxiii. 149–151 (Abs.)
"	Purification de l'yttria. (Read Oct. 11.)	'C. R.' ciii. 627–629; 'Nature,' xxxiv. 612 (Abs.); 'Chem. News,' liv. 225 (Abs.); 'Ber.' xix. Referate, 810 (Abs.); 'J. Chem. Soc.' lii. 13–14 (Abs.)

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Lecoq de Boisbaudran.	Fluorescence des composés du bismuth soumis à l'effleuve électrique dans le vide. (Read Oct. 11.)	'C. R.' ciii. 629–631; 'Nature,' xxxiv. 612 (Abs.); 'Chem. News.' liv. 225 (Abs.); 'Ber.' xix. Referate, 810–811 (Abs.); 'J. Chem. Soc.' lii. 4 (Abs.); 'Beiblätter,' xi. 39 (Abs.); 'Am. J.' [3] xxxiii. 149–151 (Abs.)
G. Krüss . .	Ueber die Oxyde des Goldes. (Read Oct. 11.)	'Ber.' xix. 2541–2549; 'J. Chem. Soc.' lii. 15–16 (Abs.)
N. Pringsheim .	Ueber die chemischen Theorie der Chlorophyllfunction, und die neuere Versuche die Kohlensäure ausserhalb der Pflanze durch dem Chlorophyllfarbstoff zu zerlegen.	'Ber. deutsch bot. Ges.' 1886, lxxix–lxxxix; 'Beiblätter,' xi. 256–257 (Abs.)
" .	Zur Beurtheilung der Engel mann'schen Bacterien-methode in ihrer Brauchbarkeit zur quantitativen Bestimmung der Sauerstoffabgabe im Spectrum.	'Ber. deutsch bot. Ges.' 1886, xc.–xcvi.; 'Beiblätter,' xi. 256 (Abs.)
J. W. Brühl . .	Untersuchungen über die Molecularrefraction organischer flüssiger Körper von grossem Farbenzerstreuungsvermögen. (Read Oct. 25.)	'Ber.' xix. 2746–2762; 'J. Chem. Soc.' lii. 191–195 (Abs.); 'Beiblätter,' xi. 240–244 (Abs.)
Hénocque . .	L'hématoscopie: méthode nouvelle d'analyse du sang, basée sur l'emploi du spectroscope. (Read Nov. 2.)	'C. R.' ciii. 817–820; 'Nature,' xxxv. 48 (Abs.); 'Ber.' xx. Referate, 25 (Abs.); 'J. Chem. Soc.' lii. 312 (Abs.); 'Zeitschr. f. Instrumentenkunde,' vii. 220–221 (Abs.)
J. Thomsen . .	Ueber den vermeintlichen Einfluss der mehrfachen Bindungen auf die Molecularrefraction der Kohlenwasserstoffe. (Oct. 1886. Read Nov. 8.)	'Ber.' xix. 2837–2843; 'J. Chem. Soc.' lii. 198–200 (Abs.)
W. N. Hartley .	Spectroscopic Notes on the Carbohydrates and Albuminoids from Grain. (Read Nov. 18.)	'J. Chem. Soc.' li. 58–61; 'Chem. News,' liv. 270 (Abs.); 'Beiblätter,' xi. 437–438 (Abs.)
" .	Researches on the Relation between the Molecular Structure of Carbon Compounds and their Absorption Spectra. Part VIII. A Study of Coloured Substances and Dyes. (Read Nov. 18.)	'J. Chem. Soc.' li. 152–202; 'Chem. News,' liv. 269–270 (Abs.); 'Ber.' xx. Referate, 131–132 (Abs.); 'Beiblätter,' xi. 537–538 (Abs.)
G Krüss . .	Untersuchungen über das Gold. II. Mittheilung. (Recd. Nov. 20.)	'Ann. der Chemie,' ccxxxviii. 30–77; 'J. Chem. Soc.' lii. 554–555 (Abs.); 'Beiblätter,' xi. 703–704 (Abs.)

Chemical Relations, 1886, 1887.

H. W. Vogel . .	Ueber neue Fortschritte in dem farbenempfindlichen photographischen Verfahren. (Read Nov. 25.)	'Sitzungsb. Acad. Berlin, 1886, 1205–1208; 'Beiblätter,' xi. 255–256 (Abs.)
N. Kowalewsky .	Über die Bildung von Methämoglobin im Blut unter Einwirkung von Alloxantin. (Dec. 2.)	'Centralbl. f. d. med. Wissensch.' 1887, 1–3, 17–18; 'Chem. Centr.' 1887, 164 (Abs.); 'J. Chem. Soc.' lii. 508 (Abs.); 'Ber.' xx. Referate, 652–653 (Abs.)
Lecoq de Boisbaudran.	Sur la fluorescence rouge de l'alumine. (Read Dec. 6.)	'C. R.' ciii. 1107; 'Nature,' xxxv. 168 (Abs.); 'Chem. News,' liv. 322 (Abs.); 'Ber.' xx. Referate, 5 (Abs.); 'J. Chem. Soc.' lii. 191 (Abs.); 'Am. J.' [3] xxxiii. 149–151 (Abs.); 'Beiblätter,' xi. 780–781 (Abs.)
J. W. Brühl .	Ueber Herrn Julius Thomsen's vermeintliche Aufklärung der Molecularrefractions-Verhältnisse. (Read Dec. 13.)	'Ber.' xix. 3103–3108; 'J. Chem. Soc.' lii. 200 (Abs.)
E. Schunck . .	Contributions to the Chemistry of Chlorophyll. No. II. (Recd. Nov. 25. Read Dec. 16.)	'Proc. Roy. Soc.' xlii. 184–188, xli. 465–466 (Abs.); 'Ber.' xx. Referate, 724–726 (Abs.); 'J. Chem. Soc.' lii. 972 (Abs.)
G. J. Burch . .	Further Experiments on Flame .	'Nature,' xxxv. 165.
C. Krukenberg .	Ueber das Spectralverhalten einiger physiologisch und klinisch interessanten Farbenreactionen. ('Chem. Untersuch. zur wissenschaft. Medicin,' Jena, 1886, 74.)	'Zeitschr. f. anal. Chem.' xxvi. 672 (Abs.); 'Chem. News,' lvii. 231 (Abs.)
E. Hering . .	Spectroskopische Methode zum Nachweis des Blutfarbstoffs. ('Prager medic. Wochenschrift,' 1886, 97.)	'Zeitschr. f. anal. Chem.' xxvi. 124 (Abs.); 'Chem. News,' lvi. 105 (Abs.)

1887.

Hoppe-Seyler. .	Caractères distinctifs des colorations de l'urine par l'acide chrysophanique et la santonine.	'J. de. Pharm.' xv. 35; 'Chem. News,' lv. 70 (Abs.)
A. W. Hofmann .	Ueber das Chinolinroth. (Read Jan. 10.)	'Ber.' xx. 4–20.
K. Olszewski . .	Über das Absorptions-Spectrum des flüssigen Sauerstoffes und der verflüssigten Luft. (Read Jan. 20.)	'Sitzungsb. Wien. Akad.' xcv. II. 257–261; 'Monatsh. f. Chemie,' viii. 73–77; 'Nature,' xxxvi. 42 (Abs.); 'Ber.' xx. Referate, 245–246 (Abs.); 'J. Chem. Soc.' lii. 625 (Abs.); 'Am. J.' [3] xxxiv. 63–64 (Abs.)

CHEMICAL RELATIONS, 1887.

F. Krüger . .	Beobachtungen über die Absorption des Lichtes durch das Oxyhämoglobin.	'Zeitschr. f. Biol.' xxiv. 47–66; 'J. Chem. Soc.' lii. 1126–1127 (Abs.); 'Ber.' xxi. Referate, 64 (Abs.)
R. Nasini . .	Sulla rifrazione moleculare delle sostanze organiche dotate di forte potere dispersivo. (Note I. Read Feb. 6, Note II. Feb. 20.)	'Rend. Acc. Roma,' [4] iii. 1st semestre, 128–133, 164–172; 'Gazz. chim. ital.' xvii. 48–55, 55–64; 'Ber.' xx. Referate, 498 (Abs.); 'Beiblätter,' xi. 579–580 (Abs.)
C. Liebermann and W. Wense.	Zur Kenntniss der färbenden Oxyanthrachinone. (Read Feb. 28.)	'Ber.' xx. 862–866.
E. Demarçay . .	Sur les terres de la cérite. (Read Feb. 28.)	'C. R.' civ. 580.
H. W. Vogel . .	Ueber neue Fortschritte in dem farbenempfindlichen photographischen Verfahren.	'Zeitschr. f. Instrumentenkunde,' vii. 99–100.
E. H. Rennie .	The Colouring Matter of Drosera Whittakeri. Preliminary Notice. (Read March 3.)	'J. Chem. Soc.' li. 371–377.
H. Becquerel . .	Sur les variations des spectres d'absorption du didyme. (Read March 14.)	'C. R.' civ. 777–780; 'Nature,' xxxv. 503–504 (Abs.); 'Chem. News,' lv. 148–149; 'Ber.' xx. Referate, 246 (Abs.); 'J. Chem. Soc.' lii. 537–538 (Abs.); 'Beiblätter,' xi. 538–539 (Abs.)
Lecoq de Boisbaudran.	Sur la fluorescence rouge de l'alumine. (Read March 21.)	'C. R.' civ. 824–826; 'Nature,' xxxv. 527 (Abs.); 'Chem. News,' lv. 176 (Abs.); 'Ber.' xx. Referate, 246–247 (Abs.); 'J. Chem. Soc.' lii. 625 (Abs.); 'Beiblätter,' xi. 781 (Abs.)
A. Bernthsen and A. Goske.	Ueber Monomethyl- und Monoäthylorange und ihre Ueberführung in Dimethyl- und Diäthylthionin. (Recd. March 24. Read March 28.)	'Ber' xx. 924–934; 'J. Chem. Soc.' lii. 666–667 (Abs.)
R. E. Schmidt .	Ueber den Farbstoff des Lac-dye. (Jan. 1887. Read April 25.)	'Ber.' xx. 1285–1303.
G. Krüss and L. F. Nilson.	Studien über die Componenten der Absorptionsspectra erzeugenden seltenen Erden. (Read April 25.)	'Ber.' xx. 2134–2171; 'Nature,' xxxvi. 324 (Abs.); 'J. Chem. Soc.' lii. 890–892 (Abs.); 'Beiblätter,' xi. 707–708 (Abs.); 'Chem. News,' lvi. 74–77, 85–87, 135–137, 145–147, 154–156, 165–167, 172–173.
C. le Nobel . .	Ueber die Einwirkung von Reductionsmitteln auf Haematin und das Vorkommen der Reductionsproducte in pathologischem Harne.	'Pflüger's Archiv,' xl. 501–523; 'Chem. Centr.' 1887, 538 (Abs.); 'J. Chem. Soc.' lii. 1127 (Abs.)

CHEMICAL RELATIONS, 1887.

C. Marignac . .	Quelques réflexions sur le groupe des terres rares à propos de la théorie de M. Crookes sur la genèse des éléments.	'Arch. de Genève' [3] xvii. 373–389.
A. Hénocque . .	Note sur l'étude hématoscopique du sang dans l'intoxication par l'oxyde de carbone. (Read May 7.)	'C. R. Soc. de Biol.' [8] iv. 283–286.
G. Linossier . .	Sur une combinaison de l'hématine avec le bioxyde d'azote. (Read May 9.)	'C. R.' civ. 1296–1298; 'Chem. News,' lv. 272–273 (Abs.); 'J. Chem. Soc.' lii. 854–855 (Abs.); 'Ber.' xx. Referate, 793–794 (Abs.)
C. M. Thompson .	Note on the Spectrum of Didymium.	'Chem. News,' lv. 227; 'Nature,' xxxvi. 115; 'Beiblätter,' xii. 195 (Abs.)
G. Linossier . .	Sur une combinaison de l'hématine avec le bioxyde d'azote.	'Bull Soc. Chim.' xlvii. 758–760; 'Ber.' xx. Referate, 793–794 (Abs.); xxi. Referate, 63–64 (Abs.)
J. Blake . .	Recherches sur les relations entre les spectres des éléments des substances inorganiques et leur action biologique. (Read May 31.)	'C. R.' civ. 1544–1546; 'Chem. News,' lvi. 50–51.
J. W. Brühl . .	Ueber den Einfluss der einfachen und der sogenannten mehrfachen Bindung der Atome auf das Lichtbrechungsvermögen der Körper. Ein Beitrag zur Erforschung der Konstitution der Benzol- und der Naphthalinverbindungen. (May 1887.)	'Zeitschr. f. physikal. Chem.' i. 306–361; 'Beiblätter,' xi. 771–774 (Abs.)
C. A. MacMunn .	Further Observations on Myohæmatin and the Histohæmatins.	'J. of Physiol.' viii. 51–65; 'J. Chem. Soc.' lii. 983 (Abs.)
Lecoq de Boisbaudran.	Fluorescence rouge de la galline chromifère. (Read June 6.)	'C. R.' civ. 1584–1585; 'Chem. News,' lvi. 12 (Abs.); 'Ber.' xx. Referate, 456 (Abs.); 'J. Chem. Soc.' lii. 755 (Abs.); 'Beiblätter,' xi. 786 (Abs.)
J. Schramm and I. Zakrzewski.	Spectraluntersuchungen über die Energie der Einwirkung von Brom auf aromatische Kohlenwasserstoffe. (Read June 10.)	'Sitzungsb. Wien. Akad.' xcvi. II. 8–18; 'Monatshefte f. Chem.' viii. 299–309; 'Beiblätter,' xii. 51–52 (Abs.); 'J. Chem. Soc.' liv. 9 (Abs.); 'Ber.' xx. Referate, 530 (Abs.)
Lecoq de Boisbaudran.	Fluorescence du manganèse et du bismuth. (Read June 13.)	'C. R.' civ. 1680–1685; 'J. Chem. Soc.' lii. 873 (Abs.); 'Beiblätter,' xi. 784–785 (Abs.)

CHEMICAL RELATIONS, 1887.

H. Becquerel	Sur les variations des spectres d'absorption des composés du didyme. (Read June 13.)	'C. R.' civ. 1691–1693; 'Chem. News,' lvi. 23 (Abs.); 'Ber.' xx. Referate, 457 (Abs.); 'J. Chem. Soc.' lii 873 (Abs.); 'Beiblätter,' xii. 19 (Abs.)
J. H. Gladstone	Dispersion Equivalents. Part. I. (Recd. May 24. Read June 16.)	'Proc. Roy. Soc.' xlii. 401–410; 'Chem News,' lv. 300–304; 'Ber.' xx. Referate, 494 (Abs.); 'Beiblätter,' xi. 698–700 (Abs.); 'Nature,' xxxvi. 239 (Abs.); 'J. Chem. Soc.' liv. 389 (Abs.)
W. N. Hartley	On the Absorption-spectrum of a Base from Urine. (Appendix to a paper on the Kreatinin of Urine as distinguished from that obtained from Flesh Kreatin. II. On the Kreatinins derived from the Dehydration of Urinary Kreatin by G. S. Johnson.) (Recd. May 5. Read June 16.)	'Proc. Roy. Soc.' xliii. 529–534; 'J. Chem. Soc.' lvi. 165–166 (Abs.)
C. H. Bothamley	Ortho-chromatic Photography.	'J. Soc. Chem. Ind.' vi. 423–433; 'J. Chem. Soc.' lii. 874–877 (Abs.)
E. Prost	Sur le sulfure de cadmium colloïdal. (June 1887.)	'Bull. acad. belg.' [3] xiv. 312–321; 'Nature,' xxxvii. 23 (Abs.)
H. W. Vogel	Beziehungen zwischen Zusammensetzung und Absorptionsspectrum organischer Farbstoffe. (June 1887.)	'Sitzungsb. Berlin. Akad.' 1887, 715–718; 'J. Chem. Soc.' liv. 97 (Abs.); 'Beiblätter,' xii. 48–49 (Abs.); 'Ber.' xxi. Referate, 776 (Abs.)
Lecoq de Boisbaudran.	Fluorescence du manganèse et du bismuth. (Read July 4.)	'C. R.' cv. 45–48; 'Nature,' xxxvi. 264 (Abs.); 'Ber.' xx. Referate, 533 (Abs.); 'J. Chem. Soc.' lii. 1006–1007 (Abs.); 'Beiblätter,' xi. 784–785 (Abs.)
"	Fluorescences du manganèse et du bismuth. Remarques ou conclusions. (Read July 25.)	'C. R.' cv. 206–208; 'Nature,' xxxvi. 336 (Abs.); 'Chem. News,' lvi. 90 (Abs.); 'Ber.' xx. Referate, 533 (Abs.); 'J. Chem. Soc.' lii. 1006–1007 (Abs.)
J. W. Brühl	Ueber den Einfluss der einfachen und der sogenannten mehrfachen Bindung der Atome auf das Lichtbrechungsvermögen der Körper. Ein Beitrag zur Erforschung der Constitution der Benzol- und der Naphthalinverbindungen. (Recd. July 20. Read July 25.)	'Ber.' xx. 2288–2311; 'J. Chem. Soc.' lii. 1005 (Abs.)

CHEMICAL RELATIONS, 1887.

W. Crookes . .	Notes on the Group of Rare Earths, considered *à propos* of Mr. Crookes's Theory of the Genesis of the Elements.	'Chem. News,' lvi. 39–40.
Lecoq de Boisbaudran.	Nouvelles fluorescences, à raies spectrales bien définies. (Read Aug. 1.)	'C. R.' cv. 258–261; 'Nature,' xxxvi. 360 (Abs.); 'Chem. News,' lvi. 114 (Abs.); 'Ber.' xx. Referate, 533 (Abs.); 'J. Chem. Soc.' lii. 1008 (Abs.); 'Beiblätter,' xi. 786 (Abs.)
"	Fluorescence du spinelle. (Read Aug. 1.)	'C. R.' cv. 261–262; 'Nature,' xxxvi. 360 (Abs.); 'Chem. News,' lvi. 114 (Abs.); 'Ber.' xx. Referate, 533 (Abs.); 'J. Chem. Soc.' lii. 1005 (Abs.); 'Beiblätter,' xi. 781 (Abs.)
E. Demarçay . .	Sur les spectres du didyme et du samarium. (Read Aug. 1.)	'C. R.' cv. 276–277; 'Chem. News,' lvi. 114 (Abs.); 'Ber.' xx. Referate, 533 (Abs.); 'J. Chem. Soc.' lii. 1008 (Abs.); 'Beiblätter,' xi. 708 (Abs.)
Lecoq de Boisbaudran.	Nouvelles fluorescences à raies spectrales bien définies. (Read Aug. 8 and 16.)	'C. R.' cv. 301–304, 343–347; 'Nature,' xxxvi. 383 (Abs.), 408 (Abs.); 'Chem. News,' lvi. 139 (Abs.); 'Ber.' xx. Referate, 627 (Abs.); 'J. Chem. Soc.' lii. 1008 (Abs.); 'Beiblätter,' xi. 786 (Abs.)
A. E. Tutton . .	The Chemistry of the Rare Earths.	'Nature,' xxxvi. 357–358.
W. Crookes . .	On a Sharp Line Spectrum of Phosphorescent Alumina.	'Chem. News,' lvi. 59–62, 72–74; 'J. Chem. Soc.' lii. 1069–1070 (Abs.); 'Ber.' xxi. Referate, 277–278 (Abs.)
" . .	On Sharp Line Spectra of Phosphorescent Yttria and Lanthana.	'Chem. News,' lvi. 62, 81–82; 'J. Chem. Soc.' lii. 1070 (Abs.); 'Ber.' xxi. Referate, 278 (Abs.)
A. Michaelis . .	Zur Kenntniss der Chloride des Tellurs. (Recd. Aug. 13.)	'Ber.' xx. 2488–2492; 'Beiblätter,' xi. 778 (Abs.)
J. H. Gladstone .	Dispersion Equivalents and Constitutional Formulæ. (Brit. Assoc.)	'Nature,' xxxvi. 570 (Abs.)
G. H. Bailey . .	The Absorption Spectra of the Haloid Salts of Didymium. (Brit. Assoc.)	'Nature,' xxxvi. 570 (Abs.)
" . .	The Absorption Spectra of Rare Earths. (Brit. Assoc.)	'Nature,' xxxvi. 570 (Abs.)
" . .	Die Componenten der Absorptionsspectra erzeugenden seltenen Erden. (Recd. Oct. 8.)	'Ber.' xx. 2769–2770; 'J. Chem. Soc.' liv. 1 (Abs.)

CHEMICAL RELATIONS, 1887, 1888.

Lecoq de Boisbaudran.	Nouvelles fluorescences à raies spectrales bien définies. (Read Oct. 31.)	'C. R.' cv. 784–788; 'Nature,' xxxvii. 47 (Abs.); 'Chem. News,' lvi. 259 (Abs.); 'Ber.' xx. Referate, 773 (Abs.); 'J. Chem. Soc.' liv. 97 (Abs.); 'Beiblätter,' xii. 196 (Abs.)
G. Krüss and L. F. Nilson.	Die Componenten der Absorptionsspectra erzeugenden seltenen Erden. (Recd. Nov. 12. Read Nov. 14.)	'Ber.' xx. 3067–3072.
S. Meunier . .	Les météorites et l'analyse spectrale. (Read Nov. 28.)	'C. R.' cv. 1095–1097; 'Chem. News,' lvi. 279 (Abs.)
C. Graebe . .	Ueber Auramin. (Recd. Dec. 1.)	'Ber.' xx. 3260–3268.
G. H. Bailey . .	Die Componenten der Absorptionsspectra erzeugenden seltenen Erden. (Recd. Dec. 14.)	'Ber.' xx. 3325–3327.
L. Lewin and C. Posner.	Zur Untersuchung des Harns auf Blutfarbstoff. ('Centralb. f. die medicin. Wissenschaften,' 1887, 354.)	'Zeitschr. f. anal. Chem.' xxvi. 672 (Abs.); 'Chem. News,' lvii. 231 (Abs.)
C. H. Wolff . .	Der spectroskopische Nachweis kleinster Blutmengen im Harn und anderen Flüssigkeiten. (Pharm. Centralhalle (N.F.) 8 Jahrg. 1887, 637.)	'Zeitschr. f. anal. Chem.' xxviii. 265–266; 'Chem. News,' lx. 50 (Abs.)

1888.

J. N. Lockyer .	Notes on the Spectrum of the Aurora. (Recd. Jan. 9. Read Jan. 19.)	'Proc. Roy. Soc.' xliii. 320–322; 'Nature,' xxxvii. 358–359; 'Beiblätter,' xii. 663 (Abs.)
J. W. Brühl . .	Untersuchungen über die Terpene und deren Abkömmlinge. (I. Mittheilung.) (Recd. Dec. 30, 1887. Read Jan. 22, 1888.)	'Ber.' xxi. 145–179; 'J. Chem. Soc.' liv. 377–378 (Abs.)
K. Seubert . .	Die Benzylester der chlorsubstituirten Essigsäuren. (Recd. Jan. 19. Read Jan. 22.)	'Ber.' xxi. 281–285; 'Beiblätter,' xii. 234–235 (Abs.)
J. W. Brühl . .	Untersuchungen über die Terpene und deren Abkömmlinge. (II. Mittheilung.) (Recd. Jan. 17. Read Feb. 13.)	'Ber.' xxi. 457–477.
Lecoq de Boisbaudran.	À quels degrés d'oxydation se trouvent le chrome et le manganèse dans leurs composés fluorescents? (Read Feb. 13.)	'C. R.' cvi. 452–455.
G. Krüss and L. F. Nilson.	Die Componenten der Absorptionsspectren erzeugenden seltenen Erden. (Recd. Feb. 17.)	'Ber.' xxi. 585–588.
O. Wallach . .	Ueber die Benutzbarkeit der Molecularrefraction für Constitutionsbestimmungen innerhalb der Terpengruppe. (Read Feb. 28.)	'Ann. d. Chem.' ccxlv. 191–213; 'J. Chem. Soc.' liv. 845 (Abs.); 'Ber.' xxi. Referate, 312 (Abs.)

CHEMICAL RELATIONS, 1888.

L. v. Udránsky .	Ueber Furfurolreactionen. (Recd. March 1.)	'Zeitschr. f. physiol. Chem.' xii. 355–376; 'J. Chem. Soc.' liv. 878–880 (Abs.)
H. Deslandres .	Détermination, en longueurs d'onde, de deux raies rouges du potassium. (Read March 12.)	'C. R.' cvi. 739; 'Nature,' xxxvii. 504 (Abs.); 'J. Chem. Soc.' liv. 637 (Abs.); 'Chem. News,' lvii. 140–141 (Abs.); 'Beiblätter,' xii. 854 (Abs.)
G. D. Liveing and J. Dewar.	On the Ultra-violet Spectra of the Elements. Part III. Cobalt and Nickel. (Recd. Feb. 27. Read March 15.)	'Phil. Trans.' clxxix. 231–256; 'Proc. Roy. Soc.' xliii. 430 (Abs.); 'J. Chem. Soc.' lvi. 89 (Abs.) 'Beiblätter,' xii. 582 (Abs.)
G. H. Bailey . .	Die Componenten der Absorptionsspectren erzeugenden seltenen Erden. (Recd. March 15.)	'Ber.' xxi. 1520–1522.
H. Deslandres .	Spectre de bandes ultra-violet des composés hydrogénés et oxygénés du carbone. (Read March 19.)	'C. R.' cvi. 842–846; 'J. Chem. Soc.' liv. 637–638 (Abs.); 'Beiblätter,' xii. 854–855 (Abs.)
H. Bertin-Sans .	Sur le spectre de la méthémoglobine acide. (Read April 23.)	'C. R.' cvi. 1243–1245; 'J. Chem. Soc.' liv. 858–859 (Abs.); 'Ber.' xxi. Referate, 407 (Abs.); 'Beiblätter,' xii. 662 (Abs.)
R. Weegmann .	Über die Molekularrefraktion einiger gebromter Äthane und Äthylene und über den gegenwärtigen Stand der Landolt-Brühl'schen Theorie.	'Zeitschr. f. physikal. Chem.' ii. 218–240, 257–269; 'J. Chem. Soc.' liv. 999–1000 (Abs.); 'Ber.' xxi. Referate, 341 (Abs.), 390 (Abs.); 'Beiblätter,' xii. 779–782 (Abs.)
G. Krüss . .	Beziehungen zwischen Zusammensetzung und Absorptionsspektrum organischer Verbindungen.	'Zeitschr. f. physikal. Chem.' ii. 312–337; 'J. Chem. Soc.' liv. 1141 (Abs.); 'Ber.' xxi. Referate, 393 (Abs.); 'Beiblätter,' xii. 789–790 (Abs.)
Lecoq de Boisbaudran	Fluorescence de la chaux cuprifère. (Read May 14.)	'C. R.' cvi. 1386–1387; 'Nature,' xxxviii. 95 (Abs.); 'Chem. News,' lvii. 220 (Abs.)
H. W. Vogel .	Ueber den Unterschied zwischen Heidelbeer- und Weinfarbstoff und über spektroskopische Weinprüfung. (Recd. May 16.)	'Ber.' xxi. 1746–1753; 'J. Chem. Soc.' liv. 1137 (Abs.)
W. N. Hartley .	Researches on the Relation between the Molecular Structure of Carbon compounds and their Absorption-spectra. (Part IX.) On Isomeric Cresols, Dihydroxybenzenes, and Hydroxybenzoic Acid. (Read May 17.)	'J. Chem. Soc.' liii. 641–663; 'Beiblätter,' xii. 791 (Abs.)

CHEMICAL RELATIONS, 1888.

W. N. Hartley .	Proof of the Identity of Natural and Artificial Salicylic Acid. (Read May 17.)	'J. Chem. Soc.' liii. 664.
H. Becquerel . .	Sur les variations des spectres d'absorption des composés du didyme.	'Ann. Chim. et Phys.' [6] xiv. 257–279; 'Beiblätter,' xiii. 217–218 (Abs.)
J. H. Gladstone and W. Hibbert.	The Optical and Chemical Properties of Caoutchouc. (Read June 7.)	'J. Chem. Soc.' liii. 679–688; 'Chem. News,' lvii. 247 (Abs.); 'Ber.' xxi. Referate, 573–574 (Abs.)
Lecoq de Boisbaudran.	Fluorescence de la chaux ferrifère. (Read June 18.)	'C. R.' cvi. 1708–1710; 'Nature,' xxxviii. 216 (Abs.); 'Chem. News,' lviii. 12 (Abs.); 'J. Chem. Soc.' liv. 1001 (Abs.); 'Ber.' xxi. 599 (Abs.)
E. Schunck . .	Contributions to the Chemistry of Chlorophyll. No. III. (Recd. June 19. Read June 21.)	'Proc. Roy. Soc.' xliv. 448–454; xliv. 378 (Abs.); 'J. Chem. Soc.' lvi. 279–280 (Abs.); 'Ber.' xxi. Referate, 268–270 (Abs.)
Lecoq de Boisbaudran.	A quels degrés d'oxydation se trouvent le chrome et le manganèse dans leurs composés fluorescents? (Read June 25.)	C. R.' cvi. 1781–1784; 'Nature,' xxxviii. 239 (Abs.); 'J. Chem. Soc.' liv. 1001 (Abs.); 'Ber.' xxi. Referate, 599 (Abs.)
P. Kiesewetter and G. Krüss.	Beiträge zur Kenntniss der Absorptionsspectra erzeugenden seltenen Erden. (Recd. June 22. Read July 9.)	'Ber.' xxi. 2310–2320; 'Nature,' xxxviii. 326–327 (Abs.); 'J. Chem. Soc.' liv. 1038–1040 (Abs.); 'Beiblätter,' xiii. 19 (Abs.).
A. Schoeller . .	Ueber das Hystazarin. (Read July 23.)	'Ber.' xxi. 2503–2505; 'J. Chem. Soc.' liv. 1203–1204 (Abs.)
Lecoq de Boisbaudran.	A quels degrés d'oxydation se trouvent le chrome et le manganèse dans leurs composés fluorescents? (Read July 30, Sept. 3, 10.)	'C. R.' cvii. 311–314, 468–471, 490–494; 'Chem. News,' lviii. 170 (Abs.), 183 (Abs.); 'J. Chem. Soc.' liv. 1229 (Abs.), lvi. 2 (Abs.); 'Ber.' xxi. Referate, 705–706 (Abs.); 'Beiblätter,' xiii. 19 (Abs.)
C. Liebermann .	Ueber die Spectra der Aether der Oxyanthrachinone. (Recd. Aug. 1)	'Ber.' xxi. 2527; 'J. Chem. Soc.' liv. 1203 (Abs.)
P. Kiesewetter and G. Krüss.	Contributions to a Knowledge of the Rare Earths which produce Absorption Spectra.	'Chem. News,' lviii. 75–76, 91–93.
C. Knops. . .	Ueber die Molecularrefraction der isomeren Fumar- Malëinsäure, Mesacon- Citracon- Itaconsäure und des Thiophens, und ihre Beziehung zur chemischen Constitution dieser Substanzen. (Recd. Aug. 20.)	'Ann. d. Chem.' ccxlviii. 175–231; 'Ber.' xxii. Referate, 86 (Abs.); 'J. Chem. Soc.' lvi. 198 (Abs.)

CHEMICAL RELATIONS, 1888, 1889—THEORETICAL, 1882, 1883.

B. Walter . .	Ueber den Nachweis des Zerfalles von Moleculargruppen in Lösungen durch Fluorescenz- und Absorptionserscheinungen. (Sept. 1888.)	'Ann. Phys. u. Chem.' N.F. xxxvi. 518–532; 'J. Chem. Soc.' lvi. 554–555 (Abs.)
E. Becquerel . .	Sur la préparation des sulfures de calcium et de strontium phosphorescents. (Read Dec. 3.)	'C. R.' cvii. 892–895; 'J. Chem. Soc.' lvi. 198–199 (Abs.)
W. N. Hartley .	Ultraviolet Spectra of the Elements.	'Chem. News,' lviii. 304–305; 'Beiblätter,' xiii. 217 (Abs.)
L. Hermann . .	Notiz betr. das reducirte Hämoglobin.	'Pflüger's Archiv,' xliii. 235; 'Zeitschr. f. anal. Chem.' xxviii. 265 (Abs.); 'Chem. News,' lx. 50 (Abs.); 'J. Chem. Soc. lvi. 530 (Abs.)

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G. Ciamician . .	Ueber die physikalischen Eigenschaften des Benzols und des Thiophens. (Recd. Jan. 9. Read Jan. 14.)	'Ber.' xxii. 27–30.
Lecoq de Boisbaudran.	Sur le gadolinium de M. de Marignac. (Read Jan. 28.)	'C. R.' cviii. 165–168; 'J. Chem. Soc.' lvi. 455–456 (Abs.)
E. Wertheimer and E. Meyer . .	Sur l'apparition rapide de l'oxyhémoglobine dans la bile et sur quelques caractères spectroscopiques normaux de ce liquide. (Read Feb. 18.)	'C. R.' cviii. 357–359; 'J. Chem. Soc.' lvi. 636–637 (Abs.); 'Ber.' xxii. Referate, 273 (Abs.)
W. Crookes . .	Recent Researches on the Rare Earths as interpreted by the Spectroscope. (Presidential Address, Chemical Society, March 21.)	'J. Chem. Soc.' lv. 255–285; 'Nature,' xxxix. 537–543; 'Chem. News,' lx. 27–30, 39–41, 51–53, 63–66.
O. Wallach . .	Ueber die Molecularrefraction des Camphens.	'Ann. d. Chem.' cclii. 136–140.
P. Barbier and L Roux.	Recherches sur la dispersion dans les composés organiques. (Read June 17.)	'C. R.' cviii. 1249–1251.
A. Letellier . .	Recherches sur la pourpre produite par le *Purpura lapillus.* (Read July 8.)	'C. R.' cix. 82–85; 'Chem. News,' lx. 49–50 (Abs.)

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1882.

H. Merczyng . .	Ein Beitrag zur Theorie der Diffraction des Lichtes au reflectirenden Gittern. Das Minimum der Ablenkung der gebeugten Strahlen. (Polnische Wissensch. Jahrgänge, iii. 119–128.)	'Beiblätter,' viii. 387–388 (Abs.)

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C. E. de Klercker .	Recherches sur la dispersion prismatique de la lumière. Second mémoire. (Read May 9.)	'Bihang till K. Svenska Vet. Akad. Handl.' viii. No. 10, 36 pp.; 'Beiblätter,' vii. 890–891 (Abs.)

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A. Wüllner . .	Ausdehnung der Dispersionstheorie auf die ultrarothen Strahlen. (Read May 3.)	'Sitzungsb. k. bayerischen Akad.' 1884, 245–252; 'Ann. Phys. u. Chem.' N.F. xxiii. 306–312; 'Am. J.' [3] xxviii. 457 (Abs.)
W. Voigt . .	Ueber die Theorie der Dispersion und Absorption, speciell über die optischen Eigenschaften des festen Fuchsins. (June 1884. Read July 5.)	'Göttinger Nachrichten,' 1884, 261–283; 'Ann. Phys. u. Chem.' N.F. xxiii. 554–577.
N. Piltschikoff .	Sur quelques nouvelles démonstrations des conditions du minimum de déviation d'un rayon par un prisme. (In Russian.)	'J. soc. phys.-chim. russe,' xvi. 539–551.

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J. v. Hepperger .	Über die Verschiebung des Vereinigungspunktes der Strahlen beim Durchgang eines Strahlenbüschels monochromatischen Lichtes durch ein Prisma mit gerader Durchsicht. (Read March 5.)	'Sitzungsb. Wien. Akad.' xci. II. 640–666; 'Beiblätter,' x. 282 (Abs.)
F. Exner . .	Ueber eine neue Methode zur Bestimmung der Grösse der Moleküle. (Read April 16.)	'Sitzungsb. Wien. Akad.' xci. II. 850–879; 'Monatshefte,' vi. 249–278; 'Ber.' xviii. Referate, 355–357 (Abs.)
Duhem . . .	Sur le renversement des raies du spectre.	'J. de Phys.' [2] iv. 221–225; 'Beiblätter,' x. 30–31 (Abs.)
H. Krüss . .	Ueber Spectral-Apparate mit automatischer Einstellung.	'Zeitschr. f. Instrumentenkunde,' v. 181–191, 232–244.
E. Lommel . .	Zur Theorie der Fluorescenz . .	'Ann. Phys. u. Chem.' N.F. xxv. 643–655.
G. Krüss . .	Ueber innere Molekularbewegung. (Recd. Oct. 8. Read Oct. 12.)	'Ber.' xviii. 2586–2591; 'J. Chem. Soc.' l. 14 (Abs.).

1886.

T. Liebisch . .	Ueber die Bestimmung der Lichtbrechungsverhältnisse doppeltbrechender Krystalle durch Prismenbeobachtungen.	'N. Jahrb. f. Mineral.' 1886, i. 14–34; 'Beiblätter,' x. 106 (Abs.)
E. Branly . . .	Sur la formule des réseaux plans .	'J. de Phys.' [2] v. 73–76.
Goldhammer . .	Théorie de la réfraction et de la dispersion de la lumière dans les cristaux. (April 1886. In Russian.)	'J. soc. phys.-chim. russe, xviii. 239–267; 'Beiblätter,' xi. 343–346 (Abs.)
K. von der Mühll .	Ueber Green's Theorie der Reflexion und Brechung des Lichtes. (May 1886.)	'Math. Ann.' xxvii. 506–514; 'Beiblätter,' xi. 40–41 (Abs.)
Max Born . .	Beiträge zur Bestimmung der Lichtbrechungsverhältnisse doppeltbrechender Krystalle durch Prismenbeobachtungen. (June 1886.)	'N. Jahrb. f. Mineral.' v. Beilage Band, 1–51; 'Beiblätter,' xi. 440–441 (Abs.)

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E. Ketteler . .	Constanz des Refractionsvermögens. (Oct. 1886.)	'Ann. Phys. u. Chem.' N.F. xxx. 285–299.
,, .	Zur Handhabung der Dispersionsformeln. (Nov. 1886.)	'Ann. Phys. u. Chem.' N.F. xxx. 299–316.

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Wl. Michelson .	Essai thèorique sur la distribution de l'energie dans les spectres des solides.	'J. phys. chem. soc. russe,' [4], xix. 79–98; 'J. de Phys.' [2], vi. 467–479 (Abs.); 'Phil. Mag.' [5], xxv. 425–435 (Abs.); 'Beiblätter,' xii. 658–661 (Abs.)
A. Grünwald .	Mathematische Spectralanalyse des Magnesiums und der Kohle. (Read Dec. 1.)	'Sitzungsb. Wien. Akad.' xcvi. II. 1154–1216; 'Monatshefte f. Chem.' viii. 650–712; 'J. Chem. Soc.' liv. 389–390 (Abs.); 'Beiblätter,' xii. 661–662 (Abs.); 'Chem. News,' lviii. 309–310 (Abs. of portion).

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,, . .	Mathematical Spectral Analysis of Magnesium and Carbon.	'Phil. Mag.' [5] xxv. 343–350 (Abs.); 'J. Chem. Soc.' liv. 882–883 (Abs.)
E. Wilson . .	The Law of Dispersion . . .	'Phil. Mag.' [5] xxvi. 385–389; 'Beiblätter,' xiii. 162 (Abs.)
E. Ketteler .	Grundzüge einer neuen Theorie der Volum- und Refraktionsäquivalente. (Oct. 1888.)	'Zeitschr. für physikal. Chem.' ii. 905–919; 'Ber.' xxii. Referate, 89 (Abs.); 'J. Chem. Soc.' lvi. 326–327 (Abs.); 'Beiblätter,' xiii. 488–490 (Abs.)
Sir W. Thomson .	On the Reflexion and Refraction of Light.	'Phil. Mag.' [5] xxvi. 414–425.
,, .	Note on his Article on Reflexion and Refraction of Light in the November number. (Nov. 1.)	'Phil. Mag.' [5] xxvi. 500–501.
R. T. Glazebrook .	On the Application of Sir William Thomson's Theory of a Contractile Æther to Double Refraction, Dispersion, Metallic Reflexion, and other Optical Problems.	'Phil. Mag.' [5] xxvi. 521–540.

1889.

E. Conrady . .	Berechnung der Atomrefraktionen für Natriumlicht.	'Zeitschr. für physikal. Chem.' iii. 210–227; 'Ber.' xxii. Referate, 224 (Abs.); 'Beiblätter,' xiii. 491–492 (Abs.)

Report of the Committee, consisting of General PITT-RIVERS, Dr. GARSON, *and* Mr. BLOXAM, *appointed for the purpose of calculating the Anthropological Measurements taken at Bath.* (*Drawn up by* Dr. GARSON, *Secretary.*)

ENCOURAGED by the interesting and instructive results obtained from the Anthropometric Laboratory instituted in connection with the Anthropological Section at the Manchester meeting of the Association, it was thought desirable to continue the anthropometric observations at the Bath meeting last year. A convenient laboratory was placed at the disposal of the sectional officers (with whom the idea of these observations first originated) in the building assigned as the meeting-place of the Anthropological Section. Mr. Francis Galton very kindly lent a large number of the instruments required for making tests, and permitted the superintendent of his anthropometric laboratory at South Kensington—Sergeant Randall—to go to Bath, to carry on the work of the laboratory under our superintendence.

From experience gained in the laboratory at the Manchester meeting, it was considered desirable to make a few alterations in the list of tests employed, as some of the observations required more time to make than it was possible to devote to them, except with a much larger staff of assistants than could be obtained qualified to conduct anthropometric researches. The system of measurement had, unfortunately, to be varied also in some cases, to suit the instruments, from the metric system to inches and pounds, which, though perhaps more intelligible to the persons measured, has added considerably to the work of calculating and comparing the statistics of this meeting. Much interest in the laboratory was taken by members of the Association, of whom many more than it was possible to examine were desirous of having themselves measured and their capabilities tested. The measurements and other tests, having been made by Sergeant Randall, Mr. Bloxam, and Dr. Garson, are probably more accurate and more homogeneous than those made at the Manchester meeting, where assistance had to be obtained from several gentlemen not previously experienced in anthropological work. On the other hand, the observations made are not quite so numerous, and the number of persons measured is fewer.

The characters examined were the following: The height when standing and sitting, the span of the arms, the length of the fore-arm from the elbow to the tip of the middle finger, the maximum length and breadth of the head, face, and nose; the breathing capacity; the strength of squeeze; the weight; the sense of distinguishing colour; the judgment of the eye, as estimated by the error in dividing a line into two and three parts of equal length, and in demonstrating an angle of 90 and another of 60 degrees. Note was also made of the colour of the hair and eyes, the sex, age, birthplace, and occupation (if any) of each individual examined.

During the course of the meeting the Committee of the Anthropological Section had under consideration the desirability of making more efficient provision for the laboratory at future meetings. It was considered undesirable to have to borrow instruments each year, when for a small sum the most necessary instruments could be purchased. Accordingly the present Committee was nominated, and an application was made for two sums of money to be placed at its disposal, one for the purchase

of instruments, the other for calculating the anthropometric measurements taken at Bath. On being informed that there would be some difficulty in obtaining money for the former purpose, members of the Committee very generously opened a subscription among themselves, and a sum amounting to about 14*l.* was promised. It was stipulated by the subscribers that the instruments purchased with this sum, when not in use at the Association meeting shall be kept for use in the Anthropological Institute of Great Britain and Ireland. During the year the Committee has procured the most necessary instruments, which will be in use in the laboratory at the Newcastle meeting this year. When the list of the instruments purchased is submitted in the next report of the Committee it will be seen that to have anything like a completely equipped laboratory several more instruments are required. It is to be hoped that means will be found to supply the deficiencies as soon as possible.

In compiling the results of the Laboratory at Bath, the system of Centesimal Grades introduced by Mr. Francis Galton has been employed, as being less laborious to work out, and giving much more information than the ordinary method of averages. While the following statistics deal only with the results of the measurements at Bath, a complete record has been made of these along with the previous observations at Manchester. When this has been done for a few years it is hoped that a valuable series of observations on the physical development of the educated classes at various ages will be available for scientific purposes.

Standing Height.

The stature was measured by taking the height of the person in shoes and subtracting afterwards the thickness of the heel. In the males the actual stature varies from 61 to 74 inches, the mid-stature being as nearly as possible 67 inches, the 25th grade being 65·5 and the 75th grade 69·5 inches: the mean deviation is therefore 2 inches. It may be stated here that the average stature obtained in the usual way is 67·9. In this instance it will be noted there is a considerable difference between the average and median stature. The standing height of the females varies from 57 inches to 68 inches, the mid-stature being 62·5, the 25th grade 60·8, and the 75th 63 8 inches: the probable deviation is therefore 1·5 inches. The following is the table of results of this measurement:—

Stature of Males.

Stature in inches . . .	61	62	63	64	65	66	67	68	69	70	71	72	73	74
Total observations, 73 . .	1	0	1	6	6	9	14	8	7	7	5	8	0	1
Abscissæ, 0–73 . . .	1	1	2	8	14	23	37	45	52	59	64	72	72	73

Stature of Females.

Stature in inches .	57	58	59	60	61	62	63	64	65	66	67	68
Total observations, 95 .	2	3	2	7	12	15	14	19	8	7	4	2
Abscissæ, 0–95 . .	2	5	7	14	26	41	55	74	82	89	93	95

Sitting Height.

The sitting height varies in the males from 33 to 39 inches, the mid-sitting height being 35 inches, while at the 25th grade it is 34·4 inches and at the 75th grade 36·4 inches, giving a probable deviation of 1 inch. In the females the sitting height varies from 30 to 36 inches; the mid-sitting height is 33·8, the 25th grade 32·4, the 75th grade 34·2 inches, giving a probable deviation of ·9 inch. The following is the detailed table of results:—

Males.

Sitting height in inches . .	33	34	35	36	37	38	39
Total observations, 73 . .	5	6	26	14	14	5	3
Abscissæ, 0–73	5	11	37	51	65	70	73

Females.

Sitting height in inches . .	30	31	32	33	34	35	36
Total observations, 96 . .	1	3	10	24	31	18	9
Abscissæ, 0–96	1	4	14	38	69	87	96

Span of Arms.

The span of the arms in the males varies from 64 to 76 inches; the mid-span is 69·8 inches, the 25th grade-span is 67·4 inches, the 75th grade is 71·5 inches, and the mean deviation is 2 inches. In the females the span varies somewhat more, measuring from 56 to 71 inches. The mid-span is 62·7 inches, the 25th grade-span is 60·5 inches, the 75th grade-span is 64·5 inches, and the probable deviation is 2 inches. The span exceeds the stature in by far the greatest majority of males—indeed, the reverse obtains in only eight cases, while in four the two measurements are practically equal. The mid-stature of the males is 67 inches, while the mid-span is 69·8 inches, showing a difference of nearly 3 inches in favour of the span over the height. In the females the stature in the greater number of cases equals or exceeds the span, so that while their mid-stature is 63·8 inches their mid-span is only 62·7 inches. These results correspond to those of the Laboratory at the Health Exhibition, taken from a much larger number of cases than the present. At the Health Exhibition it was found that the mid-stature of the males was 67·9 inches and the mid-span 69·8 inches, while in the females the mid-stature was 63·3 inches and the mid-span 63 inches. The following tables give the analyses of the span in the two sexes:—

Males.

Span in inches . .	64	65	66	67	68	69	70	71	72	73	74	75	76
Total observations, 72	1	5	2	6	9	12	8	10	4	5	5	3	2
Abscissæ, 0–72 . .	1	6	8	14	23	35	43	53	57	62	67	70	72

Females.

Span in inches .	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71
Total observations, 91	1	2	5	3	7	9	11	11	15	9	11	4	2	0	0	1
Abscissæ, 0–91 .	1	3	8	11	18	27	38	49	64	73	84	88	90	90	90	91

Length of Cubit.

Cubit, or the length of the forearm and hand from the elbow to the tip of middle finger, varies from 16·5 to 20 inches in the males; the mid-cubit length is 18 inches, while the 25th grade is 17·5 and the 75th 18·4 inches; thus the probable deviation is ·45. In the females the mid-cubit length is 16·4, the 25th grade is 15·3, and the 75th 17·8 inches, giving a probable deviation of ·75 inch.

Males.

Cubit in ½-inches .	16·5	17·0	17·5	18·0	18·5	19·0	19·5	20·0
Total, 73 . . .	1	7	11	18	20	5	6	5
Abscissæ, 0–73 . .	1	8	19	37	57	62	68	73

Females.

Cubit in ½-inches	14·0	14·5	15·0	15·5	16·0	16·5	17·0	17·5	18·0	18·5
Total, 91 . .	1	2	3	10	15	23	24	9	3	1
Abscissæ, 0–91 .	1	3	6	16	31	54	78	87	90	91

Strength of Squeeze.

In both males and females the strength of squeeze with the right and left hands respectively varies considerably. Indeed, it is rare to meet with a case where the power of grasp of both hands is equal. In the majority of cases the squeeze of the right hand is stronger than that of the left, but the reverse not infrequently occurs. The following table shows the relative frequency with which this occurs:

——	Number of cases		Frequency per cent.	
	Males	Females	Males	Females
Right hand stronger . . .	42	65	59·1	72·2
Left hand stronger . . .	23	23	32·4	25 6
Both hands of equal strength .	6	2	8·5	2·2
Total number of cases . .	71	90	100·	100·

In the males the mean squeeze of both hands varies from 35 lbs. up to 110 lbs., the mid-squeeze being 72 lbs., the 25th grade 64 lbs., and the 75th 82 lbs., giving a probable deviation of 9 lbs. In the females it varies from 25 to 75 lbs., the mid-squeeze being 45 lbs. (all but a few ounces), at the 25th grade it is 38 lbs., and at the 75th grade it is 50 lbs.; the probable deviation is 6 lbs. In estimating the strength of squeeze it has been thought better to follow the rule of taking the mean between the right and left hands when there is a difference, instead of taking the greatest squeeze with either hand, as has been done by Mr. Francis Galton in the statistics of the Health Exhibition. The mean is always adopted in cases where the length of bones or limbs differs on the right and left sides of the body, and there does not appear to be any reason why an exception should be made in the case of the strength of squeeze.

Table of Squeeze of Males.

Squeeze in lbs. .	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110
Total, 73 . .	1	0	1	1	3	6	7	13	9	7	16	4	3	1	0	1
Abscissæ, 0–73 .	1	1	2	3	6	12	19	32	41	48	64	68	71	72	72	73

Table of Squeeze of Females.

Squeeze in lbs. . . .	25	30	35	40	45	50	55	60	65	70	75
Total, 91	1	6	4	19	17	20	11	8	3	1	1
Abscissæ, 0–91 . . .	1	7	11	30	47	67	78	86	89	90	91

WEIGHT.

The weight in ordinary walking costume varies in the males from 120 to 210 lbs., that is from 8 stone 8 lbs. to 15 stone, the mid-weight being 151 lbs., or 10 stone 11 lbs. The 25th grade is 182 lbs., and the 75th is 168. The probable deviation is 18 lbs.

In the females it varies from 90 lbs., or 6 stone 6 lbs., to 190 lbs. (13 stone 8 lbs.), the mid-weight being about 120 lbs., or 8 stone 8 lbs. The 25th grade is about 110 lbs. and the 75th about 132 lbs., the probable deviation being 11 lbs.

Males.

Weight . . .	120	130	140	150	160	170	180	190	200	210
Total, 73 . . .	4	11	11	9	10	11	7	4	3	3
Abscissæ, 0–73 . .	4	15	26	35	45	56	63	67	70	73

Females.

Weight	90	100	110	120	130	140	150	160	170	180	190
Total, 91	2	8	12	23	21	11	4	4	2	3	1
Abscissæ, 0–91 . . .	2	10	22	45	66	77	81	85	87	90	91

The co-relation of stature to weight is given in the following tables:—

Males.

Stature	Weight in lbs.										Totals
	120	130	140	150	160	170	180	190	200	210	
74	—	—	—	—	—	—	—	—	—	1	1
73	—	—	—	-	—	—	—	—	—	—	0
72	—	—	1	1	1	—	3	2	—	—	8
71	—	—	—	2	—	2	1	—	—	—	5
70	—	—	1	3	2	—	1	—	—	—	7
69	—	—	3	—	1	1	—	—	2	—	7
68	—	1	1	1	3	2	—	—	—	—	8
67	—	1	4	2	2	1	1	2	1	—	14
66	1	2	1	—	1	3	—	—	—	1	9
65	3	2	—	—	—	—	—	—	—	1	6
64	—	3	—	—	—	2	1	—	—	—	6
63	—	1	—	—	—	—	—	—	—	—	1
62		—	—		—	—	—	—	—	—	0
61	—	1	—	—	—	—	—	—	—	—	1
	4	11	11	9	10	11	7	4	3	3	Total, 73
	4	15	26	35	45	56	63	67	70	73	Abscissæ, 0–73

Females.

Stature	Weight in lbs.											Totals
	90	100	110	120	130	140	150	160	170	180	190	
68	—	—	—	—	—	2	—	—	—	—	—	2
67	—	—	—	1	1	—	—	—	—	1	—	3
66	—	—	1	1	1	1	2	—	1	—	—	7
65	—	—	—	1	3	1	1	1	—	1	—	8
64	1	1	3	4	5	4	—	1	—	—	—	19
63	—	—	—	6	3	—	1	—	1	1	1	13
62	—	—	5	3	4	1	—	2	—	—	—	15
61	—	4	1	2	3	—	—	—	—	—	—	10
60	1	1	—	2	1	2	—	—	—	—	—	7
59	—	1	—	1	—	—	—	—	—	—	—	2
58	—	1	2	—	—	—	—	—	—	—	—	3
57	—	—	—	2	—	—	—	—	—	—	—	2
	2	8	12	23	21	11	4	4	2	3	1	Total, 91
	2	10	22	45	66	77	81	85	87	90	91	Abscissæ, 0–91

The Head Measurements.

The cephalic index, or the proportion which the breadth of the head bears to its length, reduced to terms of 100, varies from 72 to 89 in the males, the 50th grade being 78·5, the 25th grade 76, and the 75th 80·8: the probable deviation is therefore 2·4. In the females it varies from 68 to 87, the 50th grade being 77·5, the 25th 74·5, and the 75th 80: the probable deviation is therefore 2·7.

Males.

Cephalic index	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89
Total, 66	2	2	4	1	8	7	5	9	7	7	3	2	3	3	1	1	0	1
Abscissæ, 0–66	2	4	8	9	17	24	59	38	45	52	55	57	60	63	64	65	65	66

Females.

Cephalic index . . .	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87
Total, 90	1	1	0	3	2	3	7	9	5	9	9	10	9	11	4	3	2	1	0	1
Abscissæ, 0–90 . . .	1	2	2	5	7	10	17	26	31	40	49	59	68	79	83	86	88	89	89	90

According to the international division of the Cephalic Index, 12·1 per cent. of the males are dolichocephalic (70–74·9), 45·5 per cent. are mesaticephalic (75–79·9), 33·3 per cent. are brachycephalic (80–85·9), and 9·1 are hyperbrachycephalic (85–89·9). Of the females 2·2 per cent. are hyperdolichocephalic; 16·6 are dolichocephalic, 46 7 mesaticephalic, 32·3 are brachycephalic, and 2·2 hyperbrachycephalic. It may be added that in the greatest number of male skulls the cephalic ranges from 76 to 81, while in the females the greatest number ranges from 74 to 81. Arranged in tabular form, the above results give the following percentages :—

	♂	♀
Hyperdolichocephalic	0	2·2
Dolichocephalic	12·1	16·6
Mesaticephalic	45·5	46·7
Brachycephalic	33·3	32·3
Hyperbrachycephalic	9·1	2·2
	100·	100·

The Face.

The Facial Index adopted is that of Kollmann, deduced from the length of the face from the nasion (or root of the nose) to the chin, compared with the bizygomatic or maximum width of the face; or $\frac{\text{Nasio-mental length} \times 100}{\text{Bizygomatic width}}$. Experience gained in the laboratories last year, as well as at Bath, shows that the measurements required for this index can be made with a much greater degree of accuracy than the face-line measured from the chin to the 'point sur-ciliaire' adopted by French anthropologists. The number of facial measurements obtained was comparatively few. Only those made by Mr. Bloxam and Dr. Garson have been used in the following series of results. The average facial index of ten men is 86·9, and of twenty-one women 85·7. Under the Frankfort agreement, skulls in which the index is 90 and under are termed chamæprosopic, while those above 90 are described as leptoprosopic. As the measurements of length and breadth of the face in the living do not probably differ much proportionally to those in the skull, the divisions of the index in the latter may be adopted for the former. In the case of a high index the face is long in proportion to its breadth, while the reverse holds good when the index is low. The average of males and females falls in the chamæprosopic group, or, as they are better termed, the brachyprosopic

or, according to Topinard, brachyfacial group. Analysing the individual measurements, five of the males are lepto- or dolichoprosopic, and five are brachyprosopic; while eight of the females are dolichoprosopic and thirteen brachyprosopic. The facial index of the males at the 50th grade is 86, at the 25th grade 81·5, and at the 75th 91·5, the probable deviation being 5; the facial index of the female at the 50th grade is 88·4, at the 25th grade 84·4, and at the 75th 91·8, the probable deviation being 3·7. As far as the observations show, there does not seem to be any relation between the shape of the cranium and the shape of the face.

The Nose.

The nasal index shows a considerable range of variation in both sexes. As the grouping of this index on the living does not seem to be satisfactorily arranged, no attempt will be made in the present instance to classify the results. It may be stated generally, however, that only one male and three females fall within the mesorhine group of Topinard, which has for its upper limits an index of 81·4 and its lower limits 69. All the remaining nasal indices showed the people measured to be in a greater or less degree leptorhine.

Breathing Capacity.

The breathing capacity was estimated by means of a Hutchinson spirometer, graduated to cubic inches. In the males it varies from about 120 to 310 cubic inches; the mid-breathing capacity is 217 cubic inches, at the 25th grade it is about 164 cubic inches, and at the 75th grade 248 cubic inches; the probable deviation is 42 cubic inches. In the females the vital capacity of the lungs varied from 70 to 200 cubic inches, the mid-breathing capacity being about 132 cubic inches, at the 25th grade it is 113 cubic inches, and at the 75th grade 151, giving a probable deviation of 19 cubic inches. But these comparisons between male and female breathing and general statement of range of variation require to be further analysed in order to obtain from the statistics an idea of the respiratory capabilities of the persons measured, as it is well known that the breathing capacity is influenced by age, stature, and the circumference of the chest. In the subjoined tables the statistics of breathing capacity have been arranged according to stature and age. From these it will be seen that the greatest difference between the respiratory powers of the two sexes is between 20 and 40 years of age.

Co-relation of Stature and Breathing Capacity—Males.

—	120	130	140	150	160	170	180	190	200	210	220	230	240	250	26	270	280	290	300	310	Total Cases
74	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
73	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0
72	—	1	—	—	—	—	—	—	—	1	1	1	—	—	1	2	—	1	—	1	8
71	—	—	—	—	—	—	1	—	—	—	—	1	1	—	—	1	—	—	—	—	5
70	—	—	—	—	—	—	—	—	—	—	—	—	—	2	1	2	1	—	1	—	7
69	—	—	—	—	—	—	—	1	—	1	—	1	1	1	1	—	1	—	—	—	7
68	—	—	1	—	1	—	—	2	—	—	—	1	1	—	1	—	1	—	—	—	8
67	—	—	1	1	1	1	—	1	1	1	2	2	1	—	1	—	1	—	—	—	14
66	—	—	1	—	1	1	1	—	—	—	1	3	1	—	—	—	—	—	—	—	9
65	2	—	—	—	2	—	—	—	—	1	1	—	—	—	—	—	—	—	—	—	6
64	—	2	1	1	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—	—	6
63	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	1
62	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0
61	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
	2	3	5	2	5	3	2	5	2	4	5	10	5	3	5	5	4	1	1	1	73
	2	5	10	12	17	20	22	27	29	33	38	48	53	56	61	66	70	71	72	73	Abscissæ 0–73

Co-relation of Stature and Breathing Capacity—Females.

Stature	70	80	90	100	110	120	130	140	150	160	170	180	190	200	Totals
68	—	—	—	—	—	—	—	—	—	1	1	—	—	—	2
67	—	—	—	—	1	—	—	1	1	—	1	—	—	—	4
66	—	—	—	—	—	1	—	2	—	1	—	2	—	—	6
65	—	—	—	—	—	1	1	2	1	1	1	—	1	—	8
64	—	—	—	2	—	—	3	4	3	3	2	1	—	1	19
63	—	—	—	—	2	1	2	5	1	1	1	1	—	1	15
62	—	1	—	—	2	2	2	—	5	1	1	—	—	—	14
61	1	—	—	1	2	1	1	2	—	2	—	1	—	—	11
60	—	—	—	2	1	—	4	1	—	—	—	—	—	—	8
59	1	—	—	—	1	—	—	—	—	—	—	—	—	—	2
58	1	—	—	—	1	—	1	—	—	—	—	—	—	—	3
57	—	—	—	—	—	1	—	—	—	1	—	—	—	—	2
	3	1	0	5	10	7	14	17	11	11	7	5	1	2	94
	3	4	4	9	19	26	40	57	68	79	86	91	92	94	Abscissæ 0–94

The first line of horizontal figures in the tables represents the breathing capacity given in modules of 10 cubic inches; the first vertical column indicates the stature measured in inches and the ages respectively; the column headed 120 includes a breathing capacity of from 120 cubic inches but under 130 cubic inches.

Co-relation of Age and Breathing Capacity.—Males.

	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300	310	Total
70–80	—	1	—	—	1	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	3
60–70	2	—	1	1	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5
50–60	—	1	4	—	3	1	1	—	—	1	2	2	2	—	1	—	—	—	—	—	18
40–50	—	1	—	1	1	—	1	3	1	2	2	3	1	—	1	1	—	—	1	—	19
30–40	—	—	—	—	—	1	—	1	1	1	—	—	1	—	2	—	3	1	—	1	12
20–30	—	—	—	—	—	—	—	—	—	—	—	4	1	1	1	4	1	—	—	—	12
15–20	—			—		—		—		—	1	—	—	2	—	—			—	—	3
	2	3	5	2	5	3	2	5	2	4	5	9	5	3	5	5	4	1	1	1	72 Obs.
	2	5	10	12	17	20	22	27	29	33	38	47	52	55	60	65	69	70	71	72	Abscissæ 0–72

Co-relation of Age and Breathing Capacity—Females.

—	70	80	90	100	110	120	130	140	150	160	170	180	190	200	Total
70–80	1	—	—	—	—	—	—	—	—	—	—	—	—	—	1
60–70	—	—	—	—	2	—	—	1	—	—	—	—	—	—	3
50–60	1	—	—	3	—	1	—	1	1	1	—	—	—	—	8
40–50	1	—	—	1	3	—	1	3	1	2	—	—	—	—	12
30–40	—	—	—	—	2	2	4	5	3	4	3	2	—	2	27
20–30	—	1	—	—	3	3	8	6	4	3	3	2	1	—	34
15–20	—	—	—	1	—	1	1	1	2	1	1	1	—	—	9
	3	1	0	5	10	7	14	17	11	11	7	5	1	2	94 Observations
	3	4	4	9	19	26	40	57	68	79	86	91	92	94	Abscissæ 0–94

The following table, wherein is given the average stature, average breathing capacity, and the breathing capacity per inch of stature obtained

Males.

Number of cases	Ages	Stature	Breathing Capacity	
			Total	Per inch of stature
3	15–20	70·3	242·	3·4
12	20–30	68·7	252·8	3·7
12	30–40	68·5	256·2	3·7
19	40–50	67·6	211·7	3·1
18	50–60	66·5	189·	2·8
5	60–70	66·8	141·5	2·1
3	70–80	66·7	161·8	2·4

Females.

Number of cases	Ages	Stature	Breathing Capacity	
			Total	Per inch of stature
9	15–20	62·4	147·3	2·4
34	20–30	63·1	142·2	2·2
27	30–40	63·5	150·3	2·4
12	40–50	62·4	128·6	2·
8	50–60	60·3	118·	1·9
3	60–70	63·7	121·7	1·9
1	70–80	61·	70·	1·1

from the two previous measurements at each decade of life, is interesting and instructive.

In these tables the ages, for example, from 20 to 30 include all up to 30 years, but persons of 30 years are classed in the next group. The maximum difference between the vital capacity of the lungs of males and females is between the ages of 20 and 40 years, after which the decline in the males is regular and successive, while there is less falling-off of the respiratory powers as age advances in the females. More observations are necessary before it can be determined whether this variation is due to the respiratory powers of the males failing, as life advances, more rapidly than those of females, or is the result of some other cause operating in women to prevent the full development of respiratory powers between the 20th and 40th years of life, particularly between 20 and 30 years. The fact that the vital capacity of the lungs between these years is less both actually and relatively to the stature than in young females between 15 and 20 years, while in males the reverse obtains, would tend to show that the latter hypothesis may be the correct explanation of the variation.

Colour Sense.

The test for appreciation of colour was to mark off four different shades of green wool which were mixed with various other coloured wools by placing pegs opposite each green wool. This test was satisfactorily performed by all the persons examined, so that no case of colour-blindness was observed. At the previous meeting only one person was found to be colour-blind—a gentleman of Jewish race, among whom colour-blindness is somewhat prevalent.

Judgment of Eye.

The tests of dividing a line into two and three parts of equal length and of marking off a right angle, in other words, placing a line perpendicular to a horizontal line, being easy, were fairly accurately done by both sexes. Marking off an angle of 60° proved a much more difficult task, and accuracy was attained by very few.

In dividing a line in half the female eye showed itself to be absolutely correct in ten per cent. more instances than the male, or, in actual figures, 35·6 per cent. of the males performed this test without error, while the same was done by 45·5 per cent. of the females. In 58·9 per cent. of the males the error amounted to 1 per cent., or a tenth of an inch ; the same amount of error was found in 43·2 per cent. of the females. An error of

2 per cent. was made by 4·1 per cent. of the males and by 10·2 per cent. of the females; and an error of 3 per cent. was made by 1·4 per cent. of the former and 1·1 per cent. of the latter.

The division of a line into thirds was done very equally by both sexes, that is to say, the percentage of those who were correct and of those whose error varied from 1 to 4-tenths of an inch was almost identical in both males and females.

The males were considerably better than the females in estimating a right angle, 63 per cent. being correct, while only 33·7 per cent. of the females were correct. The greatest error made by the males was 4°, while one lady was 18° wrong, and nearly 8 per cent. had errors of over 4°.

A marked falling-off in accuracy of judgment, as before stated, took place in estimating an angle of 60°, but it is only by using Mr. F. Galton's method of projecting the statistics reduced to percentages that it is possible to determine accurately whether the males or the females examined had the more accurate ideas of this angle. At the 25th grade the males show an error of 1·6°, while the female error at the same grade is 2·2°. At the 50th grade the male error is 4·7°, the female 7·7°; and at the 75th grade the error of the males is 9·5°, and of the females 9·6°. From this it will be seen that the males were rather more accurate than the females at this test, their percentage of error at the 25th and 50th grades being lower than that of the opposite sex at the same grades.

The following tables show details of the statistics relating to the judgment of the eye:—

Judgment of Eye in dividing a Line.

—	Into halves				Into thirds						
	Correct	Amount of error			Correct	Amount of error					
		$\frac{1}{10}$ in.	$\frac{2}{10}$ in.	$\frac{3}{10}$ in.		$\frac{1}{10}$ in.	$\frac{2}{10}$ in.	$\frac{3}{10}$ in.	$\frac{4}{10}$ in.	$\frac{5}{10}$ in.	$\frac{6}{10}$ in.
Males . .	35·6	58·9	4·1	1·4	17·8	34·3	24·7	15·	8·2	—	—
Females .	45·5	43·2	10·2	1·1	17·	36·4	25·	11·4	8·	1·1	1·1

Judgment of Eye in estimating Angle of 90 degrees.

—	Correct	Amount of error stated in degrees							
		1°	2°	3°	4°	8°	14°	15°	18°
Males . .	63·	30·1	2·8	4·1	—	—	—	—	—
Females . .	33·7	41·6	12·4	4·5	2·3	2·2	1·1	1·1	1·1

Judgment of Eye in estimating Angle of 60 degrees.

—	Correct	Amount of error stated in degrees																
		1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	11°	12°	13°	14°	15°	17°	20°
Males .	4·1	13·7	12·3	9·6	4·1	8·2	—	—	4·1	1·4	31·5	1·4	4·1	—	—	2·7	1·4	1·4
Females .	5·9	5·9	11·8	8·2	1·2	7·0	2·3	3·5	5·9	—	34·1	—	5·9	2·3	1·2	4·7	—	—

Colour of Eye.

The colour of the eye was observed according to Topinard's directions. The eyes were examined at such a distance from the observer that all smaller details of colour of the iris were blended together and one uniform impression was obtained. The colours are classed in three groups, viz., light or clear, including blues of all shades; medium, including grey and green tints; and dark, including brown and black. The colour of the eye in the males according to this grouping is as follows—29 light, 28 medium, 8 dark; of the females, 28 light, 37 medium, 17 dark. In both sexes, therefore, the medium, including grey and green tints, greatly predominated, while the dark was the least frequent. Of the medium tints the grey was by far the more common.

Reduced to percentages the above figures show the colour of the eye in the two sexes to be:—

	Males	Females
Light	44·6	34·2
Medium	43·1	45·1
Dark	12·3	20·7

Age.

The ages of the males examined varied from 15 to 75, while that of the females was from 17 to 71 years. The following table contains more detailed particulars on this point. It may be explained that the upper figure of each decade is not included; thus, for example, persons 30 years of age are not included in the column headed 20–30 but in that of 30–40.

Table of Ages.

—	Under 20	20–30	30–40	40–50	50–60	60–70	70–80	Total
Males	3	12	12	19	19	5	3	73
Females	9	34	30	12	8	3	1	97

Number Examined.

The total number of males examined was 73, and of females 98, making a total of 171 persons who were tested in the Laboratory at the Bath meeting of the Association. Rather more than a fourth of these belonged to Somersetshire.

By an oversight the time for drawing the sum of 5*l.* placed at the disposal of the Committee was permitted to lapse before application for the money was made, consequently no part of the sum has been received by the Committee, but liabilities have been incurred to the extent of the grant for clerical aid and other incidentals connected with the preparation of this Report and for record books, &c. The Committee therefore request that the grant made last year be continued, and that a further sum of 5*l.* be placed at its disposal for calculating and recording the results of the Laboratory to be opened at the Newcastle meeting of the Association this year. For the purpose of carrying on this work the Committee seeks to be reappointed.

Second Report of the Committee, consisting of Mr. A. W. WILLS (*Chairman*), Mr. E. W. BADGER, *and* Professor HILLHOUSE, *for the purpose of collecting information as to the Disappearance of Native Plants from their Local Habitats. By* Professor HILLHOUSE, *Secretary.*

As intimated at the close of the report for 1887 [1] the Committee have given their attention in the first instance to Scotland, and append hereto such portion of the materials placed at their disposal as, for any reason, they consider desirable to publish. They have excluded a considerable number of plants of little interest, and especially such as the records show to be recent introductions, casuals, escapes, &c., the loss of which is only a return, therefore, to an earlier, but still recent, state. There is little doubt that the list, even thus restricted, will be considerably amplified hereafter.

The plants recorded are numbered in accordance with the 'London Catalogue,' ed. 8, in which the distribution census of each plant will be found. Nearly all of the records are on the authority of some competent botanist resident in the locality, whose initials, or some distinguishing initials, are appended. As has been pointed out by more than one correspondent, scarce plants occasionally well-nigh disappear in particular seasons, and hence the records of other than frequent visitors are not fully reliable.

The attention of botanists is particularly drawn to the records under the numbers 52, 264, 374, 406, 570, 575, 687, 910, 932, 993, 1,018, 1,020, 1,478, 1,695, and 1,772, as giving examples of divers ways, often very curious and interesting, in which plants can become extinct.

The attention of the Committee's correspondents has been in the main confined to complete or threatened extinction; but in addition to this there is a general consensus of opinion that the rarer and more conspicuous Alpine plants are less abundant than they used to be. Amongst the localities specially mentioned are Clova and Ben Lawers; such plants (in addition to those given in the list) as *Saxifraga cernua*, *Alsine rubella*, *Gentiana nivalis*, &c., are notably less frequent than twenty years ago. Strange rumours have been communicated to the Committee as to the disappearance of plants from accessible habitats within the range of some of the deer 'forests,' but they are unable to verify these statements. Most of the correspondents agree, however, that the injudicious action of botanists

[1] The Committee were unable to report in 1888, having lapsed by accident.

themselves, and of botanical exchange clubs, has been a potent factor in the changes which have taken place. It is too often forgotten that the very rarity of a plant is the sign, and in great degree also the measure, of the acuteness of its struggle for existence, and that when a plant is in a state of unstable equilibrium with its environment a small disturbance may have disproportionately great effects.

It will be observed that the 'dealer' and 'collector' figure largely, especially in connection with the disappearance of ferns. Thus one of the correspondents indicates (and offers to name) a dealer who has extirpated, or well-nigh extirpated, a considerable number of species in the district of Dumfries, and whose conduct he had brought under the notice of the local Natural History Society, of which the correspondent is secretary. 'He had also removed and sold almost all of the plants of *Nymphæa alba* from the lochs of this district before discovery; but now I am happy to say he is forbidden access to any estate in this district under penalty of prosecution for trespass.' The attention of Natural History Societies may well be drawn to this case, as it happily illustrates at the same time one phase of the disease and a cure.

'Summer visitors' do not appear to be directly responsible for much damage, as their wanderings are probably over too restricted an area to produce much effect. There is no doubt, however, that they provide the larger portion of the customers of the 'collector,' and so are indirectly answerable for his ravages. The temptation to bring home some rare and beautiful fern, like *Aspidium* (*Polystichum*) *Lonchitis*, as a relic of a northern trip, is too great to be resisted, though something may possibly be done by persuading tourists that equally good plants, taken up with all proper care, and at a season when transplanting is not dangerous, can be obtained from any great fern nursery, for a price which is practically lower, often much lower, than that charged upon some Highland railway platform or roadside.

The Committee feel, however, that neither local dealers nor their customers are as a rule amenable to any ordinary appeal or to sentimental considerations, and would suggest therefore that the local Natural History Societies or Field Clubs should keep careful guard over any rare plants to be found within their respective spheres of action, and by appeal to the owner, or in other preferable way, should endeavour to effect their preservation. At the same time many correspondents draw attention to the insertion by gardening periodicals of the advertisements of collecting dealers, and express the hope that the amount of revenue derived from these advertisements is not so great as to negative the possibility that the gardening journals may be induced, by discontinuing their insertion, to strike a heavy blow at a process which is depriving many districts of our land of one of their chief natural beauties.

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39. *Trollius europæus*, L. Extinct in Mid-Aberdeen, &c. (W. W. and J. M.).

52. *Nymphæa alba*, L. Almost extirpated from lochs in the district round Dumfries by a dealer (J. W.). Has disappeared from the district of Birnie, near Elgin, by drainage (G. and T. A.).

58. *Meconopsis cambrica*, Vig. Believed to be extirpated from banks of Water of Leith and Currie, Midlothian (G. A. P.).

59. *Glaucium flavum*, Crantz. Recorded in 1776 for seashore at Bay

of Nigg, near Aberdeen, but not since 1800 (J. W. H. T.). Found sixty years ago at Montrose Links; not now (R. B.).

184. *Dianthus Armeria*, L. Occurred, though not abundantly, in rough pasture near Glencarse Station, Perthshire; has been entirely destroyed through the cultivation of the ground (F. B. W.). This was one of its most northern stations.

207. *Lychnis viscaria*, L. Blackford Hill, Midlothian; now very rare (G. A. P.). Arthur's Seat, Edinburgh; supposed to be extirpated (G. A. P.).

208. *Lychnis alpina*. Is now becoming rare in its habitats on Clova Mountains (G. A. P.).

263. *Hypericum perforatum*, L. Formerly grew plentifully near Cromarty Nursery, but has ceased to exist, as the ground is now used for agricultural purposes (T. A.). This was one of its most northern stations.

264. *Hypericum quadrangulum*, L. Has wholly disappeared from the vicinity of Fortrose, Ross-shire, having been eaten by cattle or trodden down (T. A.). This was one of its most northern stations.

368. *Lotus pilosus*, Beeke. Extinct round Alford, Mid-Aberdeenshire, from cultivation (W. W.).

374. *Oxytropis uralensis*, D. C. Grew in abundance near Invergordon, Ross-shire, but on one occasion the medical man of the town saw a man digging it up with a trowel, and it is now extinct (T. A.).

375. *Oxytropis campestris*, D. C. Rocks at Bradoony, Clova; now very rare; extirpated from all accessible parts of the rocks (G. A. P.).

406. *Lathyrus niger*, Wimm. Has well-nigh disappeared from its station at Killiecrankie Pass, owing to the late guide to the Pass showing it to all tourists. An appeal to the proprietor might save the rest of the specimens, of which very few stations exist (F. B. W.).

501. *Agrimonia Eupatoria*, L. Becoming very scarce in Glen Urquhart, Inverness-shire (Gr.). This was one of its most northern stations.

525. *Pyrus Aria*, Sm. One specimen only (? *P. fennica*, L.) known in Arran; now lost through injury (G. A. P.). Lost also from one or two other stations on the Western Highlands, and now very rare in Scotland.

570. *Sedum reflexum*, L. Found freely on a wall at Birnie, Elgin; disappeared through repairs (G.). Not native.

575. *Drosera anglica*, Huds. Extinct in Kincardine (M.). Extinct round Alford, Mid-Aberdeen, through drainage (W. W.).

577. *Hippuris vulgaris*, L. Extinct round Alford, Mid-Aberdeen, but still appears on the borders of Banffshire.

611. *Eryngium maritimum*, L. Found in the early part of the century on the sandy coast at St. Cyrus, near Montrose, and at St. Fergus, Peterhead, but extinct in both localities from unknown causes (J. W. H. T. and R. B.).

687. *Linnæa borealis*, Gronov. Has been cleared from near Dingwall, Ross-shire, owing to the wood in which it grew having been cut down and the ground cultivated (T. A.). Formerly grew at Kingsmills, but has been destroyed through cultivation (G. A., *fide* T. A.). These are two of the most northern British stations.

812. *Silybum Marianum*, Gaertn. Has gone from the rocks near Tarbet-ness Lighthouse, Ross-shire (D.). This plant is very rare in Scotland.

887. *Lactuca (Mulgedium) alpinum.* This plant was found (probably abnormally) on the Coreen Hills at about 700 feet, but is now extinct (W. W.).

910. *Vaccinium Oxycoccos*, L. Formerly grew in a piece of mossy land on the uplands north of Mealfourvouny, a hill of Old Red Sandstone conglomerate above 3,000 feet, but whether the plants were of recent introduction or last survivors, they have disappeared (Gr.).

926. *Phyllodoce taxifolia*, Salisb. (*Menziesia cærulea*). The only British habitat of this plant is the Sow of Athol, and it has now been nearly extirpated, for sale (K. and F. B. W.). The habitat is within sight of a gamekeeper's house, so that its protection would be easy if the Duke of Athol, the owner, could be moved to that effect.

929. *Pyrola media*, Sw. Has disappeared from White Hills, Colvend, Kirkcudbrightshire, through sheep grazing (J. M. A.).

932. *Moneses grandiflora*, Salisb. (*Pyrola uniflora*, L.). Extirpated from Woodhead Hill, Traqueer, Dumfriesshire (J. W.). Once not uncommon on the Muirhead of Scone; now very rare, from extirpation by botanists and others (F. B. W.). Formerly abundant within four miles of Forres; now extirpated; also from the wood at Brodie, near Forres, from the wood being cut down, and from Coul Woods, near Strathpeffer. It is also disappearing from Rothiemurchen, in this case from the rapacity of collectors (K.).

945. *Primula scotica*, Hook. Marsh near Edinburgh, Pentland Hills; practically extirpated (G. A. P.).

984. *Asperugo procumbens*, L. Has not been found for some years near the village of Balnahuish, on the Dornoch Firth (D.). This was its most northern station.

993. *Mertensia maritima*, Don. Shingle at Bay of Nigg, Aberdeen; almost extirpated from shingle being removed to form concrete blocks used in building a pier some years ago (J. W. H. T.).

1,006. *Echium vulgare*, L. Nearly extinct, through cultivation, in the Black Isle, between Inverness and Fortrose, Ross-shire (T. A.).

1,018. *Atropa Belladonna*, L. Has disappeared from Renlop Abbey, near Birnie, by extraction, on account of the accidents it had caused (G.). Has not been seen for some years at the Old Kutt, near Ganlude (T. A.). This eliminates two of the few Scottish stations.

1,020. *Hyoscyamus niger*, L. Appeared in two or three places in the neighbourhood of Avoch, a fishing village on the Moray Firth, but disappeared in a few years. Informant 'thinks it would come up again if the ground were deeply trenched. Some years ago an old elm was blown down and the root blasted, and for two succeeding summers *H. niger* grew luxuriantly in the hole caused by the tearing up of the root of the tree' (S. R. *fide* T. A.).

1,092. *Utricularia vulgaris*, and 1,094. *U. minor*, L. Extinct in Central Aberdeen (J. M. and W. W.).

1,161. *Ajuga pyramidalis.* Has disappeared from In. Achilty, Dingwall, Ross-shire (T. A.).

1,424. *Paris quadrifolia*, L. There is one station near the town of Inverness; nearly extinct, through the publicity of its habitat, this being one of the chief resorts of the population (T. A.). This is one of its most northern stations.

1,431. *Juncus balticus*, Willd. Loch of Park, and Links north of

Aberdeen; never plentiful, and not seen for some years. Cause of disappearance doubtful (J. W. H. T.).

1,457. *Sparganium ramosum*, Curtis; *S. simplex*, Huds.; *S. affine*, Sch.; and *S. minimum*, Fr. All apparently extinct in Mid-Aberdeen (W. W.).

1,478. *Scheuchzeria palustris*, L. The only Scottish station for this plant, a marsh near Methven (known botanically as 'Methven bog'), has been lost; perhaps from the outlet becoming blocked, so that more water collected than the plant could stand, but more probably from the settlement there of a large colony of about 3,000 black-headed gulls, the result being the destruction of all but the rankest vegetation (chiefly *Carex ampullacea*). Very careful searching during the last three years has failed to show a trace of the plant (F. B. W.).

1,590. *Carex limosa*, L. Has disappeared from Maxwell-town Loch, Kirkcudbrightshire, through drainage (J. M. A.).

1,695. *Melica uniflora*, Retz. Is not now found by the side of the burn at Golspie, Sutherland, probably from the hollow, caused by the upturned stool of a large tree which has been blown over, draining the spot where it grew (J.). This was its most northern Scottish station.

1,766. *Cryptogramme crispa*, R. Br. (Parsley fern). Extirpated from several localities in the vicinity of Dumfries (J. W.). Abundant thirty years ago on an ancient hill-fortress near Brechin; now extirpated by traders (R. B.).

1,772. *Asplenium viride*, Huds. Nearly extinct in district of Black Isle, between Inverness and Fortrose, through drainage and cultivation (T. A.). Has been extirpated from its old habitats in Glen Urquhart, Inverness-shire, by an itinerant fern-collector who squatted in the neighbourhood and took all he could find; but new habitats have been discovered (Gr.).

1,773. *Asplenium Trichomanes*, L. Not now found in the woods of Knockespock Clatt, Mid-Aberdeen (W. W.).

1,776. *Asplenium germanicum*, Weiss. Nearly eradicated from Stenton Rock, near Dunkeld (F. B. W.).

1,777. *Asplenium septentrionale*, Hull. Probably extirpated, or nearly so, from Arthur's Seat, Edinburgh (G. A. P.). Nearly eradicated from Stenton Rock, near Dunkeld (F. B. W.).

1,779. *Athyrium alpestre*, Milde. Now very rare in Clova Mountains and mostly in inaccessible places (G. A. P.).

1,781. *Ceterach officinarum*, Desv. Almost extirpated from Orchardtown Tower, Kirkcudbrightshire, by fern-hunters (J. M. A.). Used to grow on the walls of Drumlanrig Castle, one of the seats of the Duke of Buccleuch, Dumfriesshire, but not now found there (T. A.).

1,782. *Scolopendrium vulgare*, Symons. Almost extirpated from several places in Kirkcudbrightshire by fern-hunters (J. M. A.). Extirpated from several places in the vicinity of Dumfries (J. W.). On the burns falling into Loch Ness there is now only one in which this plant is to be found, owing to the ravages of the itinerant fern-collector referred to under 1,772. It still exists, however, in inaccessible stations (Gr.).

1,783. *Woodsia ilvensis*, R. Br. Well-nigh extirpated by fern-hunters from the Moffat district (J. W.).

1,787. *Cystopteris montana*. This plant, though not at present really uncommon round Aberfeldy, will not improbably be made very scarce by

fern-collectors. It has disappeared altogether from one of the stations in which it was first found in Britain (F. B. W.).

1,788. *Polystichum Lonchitis*, Roth. Almost extinct on Mealfourvouny Mountain, Inverness-shire, through the action of fern-collectors, and especially of the one referred to under 1,772 and 1,782 (Gr.). Has been cleared from the Raven's Rock, near Strathpeffer, Dingwall, Ross-shire, by summer visitors (T. A.). Was plentiful near Castleton, Braemar, formerly, but the guides learned that they could sell it at a shilling a plant, and it is now difficult to get (T. A.).

1,803. *Phegopteris* (*Polypodium*) *Robertiana*, A. Br.; *Polypodium calcareum*, Sm. Once abundant in the *débris* of an old limestone quarry near Aberfeldy, but now nearly eradicated. Fern-hunting visitors and tourists are largely to blame for this, but the destruction has been completed by persons who collect ferns for sale. That the species is not altogether lost in the district is, however, shown by the fact that a few weeks ago a local fern-hunter was offering plants for sale, and at the same time plants of 1,787 *Cystopteris montana* (F. B. W., July, 1887).

1,806. *Osmunda regalis*, L. Has disappeared from Ballingear Glen, New Galloway, and from other places, as Colvend, through the ravages of fern-hunters (J. M. A.). Extirpated from several localities in the vicinity of Dumfries (J. W.). Has entirely disappeared from Loch of Park, and nearly from the cliffs south of Aberdeen, in both of which localities it was formerly plentiful. Fern-collectors are mainly responsible (J. W. H. T.).

1,809. *Botrychium Lunaria*, Sw. Formerly very local in the Pentlands; now extirpated (G. A. P.).

1,818. *Equisetum hyemale*, L. Extinct in Mid-Aberdeen (J. M.).

The Incidence and Effects of Import and Export Duties.

By C. F. Bastable.

[A communication ordered to be printed *in extenso* among the Reports.]

The most difficult part of the principles of State finance is undoubtedly that which considers the incidence and effects of the various kinds of taxation, and of the subdivisions of this difficult topic the most complicated and obscure is to be found where it, as it were, intersects the field of international trade, *i.e.*, in the examination of the real effects of export and import duties.

It is true that for a full elucidation of the problem, or series of problems, different methods will have to be used in combination; but we may, I think, reasonably hold that a statement of the general conditions found in operation, and a discussion of their probable action, is an essential preliminary to any fruitful inquiry into particular cases; and it is to this side of the question that the present paper is directed. At the outset it is important to remark that the systems of import and export taxes in the various countries of the world should be treated as a whole. We cannot—except provisionally—isolate a single tax, and consider it as quite apart from the general fiscal system. Every tax imposed or abolished is likely to have effects on the course of trade in general, and the state of trade in turn reacts on each particular duty. Conclusions

derived from the study of special taxes can never be anything more than probable. All collections of fiscal statistics need careful deductive interpretation before they can be used with advantage, while analysis of the fundamental conditions requires to be fully verified, though from the nature of the case this confirmation is not easily to be obtained.

The historical development of the system of international taxation shows very clearly the character of the various taxes. The earliest form is that of the *transit duty*, which sought to gain profit by charging foreigners for the use of the roads or water-ways of a territory. Such taxes appear to be an intermediate form between import and export duties, or perhaps may be better regarded as a combination of both. They possessed the happy feature of bringing in revenue without any loss to the State or obstruction to its domestic industry. They have now, in the new position of European society, ceased to possess any practical interest, unless, indeed, the rates of international railways and inter-oceanic canals can be looked on as similar. Though the transit duty did not directly affect the subjects of the taxing State, it must, by hindering the development of the carrying trade, have reduced the gain which was derived from exchange, and in this respect it resembles its successors. Next in order of time is probably the *export duty* or toll levied on some staple commodity when sold to foreigners. Its primary object was revenue; but it is possible that even in their origin these duties were sometimes intended to benefit a favoured class, by hindering the export of an article which its members consumed. It is more important to notice that the term 'export duty' comprises two different kinds of tax—viz. (1), an excise duty *without a drawback* when the home consumers are not benefited, and (2), a simple export duty on an article untaxed for home use—the latter favours, and is generally intended to favour, the native consumer. Latest in time, but now by far the most prominent, is the *import duty*, divided into (1) revenue and (2) protective, according as the competition of home producers who are free from the tax is absent or present. Under the rule of ideas derived from the mercantile system, the simple export [1] and protective duties were objects of special favour; but State needs and, in England at least, the adoption of free trade views have now made the revenue import duty the leading tax. The effects of such duties may, therefore, be considered first.

An import tax may conveniently be described as 'a charge levied on a commodity on its entry within a given area or nation.' Popular opinions would give a very simple solution, or solutions, of its incidence, the ordinary free-trader regarding it as an additional charge on the consumer, while the protectionist, or 'fair-trader,' would probably hold that it was a toll levied on the foreign producer for the privilege of sending his wares to market. Neither of these simple and easily-stated formulas can be accepted, though the former is much nearer the truth. In fact, the incidence of an import duty depends on a number of conditions, which it is in practice very hard to estimate with any precision, but which can be indicated generally. They are (1), the conditions of demand: the imposition of a duty on an imported commodity will at first tend to raise its price, and the increased price will probably reduce demand for the commodity within the taxing nation; but the nature of the want satisfied may not allow of such a course. The consumers may take as

[1] In the case of raw materials needed for domestic manufactures.

much, or nearly as much, at the higher price as they did before, when it is plain that the bulk of the tax falls on them. In general, however, demand will be reduced, and it might therefore be contended that in such instances the whole tax would not fall on the consumer. This introduces a further element—(2), the extent of demand *outside* the taxing nation. Foreign producers will not submit to the fall of price that reduced demand will probably cause, so far as they are concerned, if there is any mode of escape; and this refuge they may have in their own and other nations' markets. So that, in addition to the consideration of the intensity of the demand in the taxing country, we have to see what proportion it bears to the total demand. To maintain that an import duty in the Channel Islands would have the same effect as one in the United States is obviously incorrect. Should the taxing country be the sole area of consumption, and should its demand be one easily checked by higher price, it would be in a specially favourable position for levying an import duty. It is not easy to find any actual case in which these conditions are realised; but many countries have a large proportion of the demand, and so far they are advantageously placed. Thus it seems likely that the import duties levied by France and Germany on cereals have checked their demand, and in some degree lowered price. Again, though a nation may have but a small proportion of the *total* demand under its control, it may be able to affect some particular group of producers, owing to situation or other causes; *e.g.*, England could, by an import duty on *Irish* cattle, seriously affect that trade—a course which would not be so easy with the American meat trade: so long as the English market gave more advantage than any other to the Irish dealer he would seek it notwithstanding the tax. (3) The existence of untaxed substitutes for the commodity also tends to check demand; but in practice this case would not be likely to occur, since it could be avoided by the imposition of equivalent duties on the competing articles. Next, a *revenue* import tax differs from a *protective* one, in that the latter, by leaving the native sources of supply untaxed, will help to limit the rise in price of the imported article, acting in the same manner as the existence of an untaxed substitute, but to the loss of the revenue to be derived from the tax so far as the consumption of the imported part of the commodity is reduced. Combining the foregoing elements, we arrive at the conclusion that import duties are not easily shifted *in toto* to the foreign producer, since, to accomplish this result, demand must be feeble, and the taxing country must have a 'consumer's monopoly.' But though this complete removal of the burden is not to be hoped for, yet, where a large proportion of the demand can be affected some of the tax will be thrown on the producing country, and in almost every case it is likely that some special classes of producers will be touched by duties imposed at their best market. Speaking generally, values (or their simplest index prices) will not be much lowered, but trade will be limited, a smaller amount of the taxed articles being imported at nearly the same price (duty apart) as before the introduction of the tax.

Given, however, the conclusion that import duties tend to fall partly on the producing countries, the question remains, What classes will endure the loss? If the industry be in its normal state, capital can only obtain ordinary interest; consequently the operation of the duty will tend to reduce the capital invested in producing the taxed commodity, since other employments will plainly be more advantageous. It is theoretically con-

ceivable that the rate of interest in general would be lowered—the capital when turned to other industries having a lower 'final utility.' Similar reasoning would apply to ordinary wages and to *normal* 'wages of superintendence,' but skilled labour would probably suffer, and so would the 'employer's gain' where it exceeds wages of superintendence and conforms to the law of rent. Where raw materials and food are subjected to duties which tend, by limiting demand, to lower price, the margin of production will be raised and rent will fall. A further mode of loss to the producing country may possibly exist, though its amount must in any actual case be very small. The effect of import duties may, as Mill has argued, be to cause a redistribution of the money-material, thus altering the scale of prices to the advantage of the country which levies the duty. Here the community suffer as consumers of the products exported from the taxing country; and it may be remarked in passing that the modern organisation of credit enables this effect to be produced without any, or with a very small, transfer of bullion.

Where import duties really lower price they have a still further effect in allowing consumers in other countries to get the particular commodity at a reduced rate. The exporter, in choosing a market, will naturally select that which is free from duty, unless he obtains a price higher by the amount of the duty in that which is subject to it; therefore any reduction of price must extend to all connected markets.[1] We have probably an illustration in the effect of the French and German corn duties (before referred to) on the price of corn in England. In the evidence taken by the Royal Commission on Depression of Trade and Industry the following statement is to be found: 'The first effect of the French and Germans recently putting on an extra duty on wheat was a reduction in the cost, freight, and insurance price of wheat destined to all the Western European markets, and therefore the duty imposed by France and Germany rather cheapened the price of wheat in the United Kingdom and Belgium, which still imports free' [L. 9,740, W. J. Harris ('Third Report,' p. 91, col. *a*)]. It is equally true that the consumer in the producing country gains by the lowered price—an advantage which may set off the possible loss through a lowered scale of prices, and where the commodity is auxiliary to other forms of production would act as a bounty to the industries so using it. Thus it is conceivable that a sugar duty in the United Kingdom which did not raise the price by the full amount of the duty would be a premium to the jam makers and biscuit manufacturers of the Continent. An effectual protective tax which undoubtedly tends to injure the foreign producers by limiting their gains would be particularly likely to have this partially compensating result. One thing, at all events, is plain, viz., that the real and direct effects of an import duty are not easily foreseen. The interests of many diverse classes of producers and consumers in the producing, the taxing, and in other nations may be variously affected. Indeed, it may be said that if explanation is difficult, prediction is well-nigh impossible—a statement which appears still more evident when we remember the indirect effects on trade in other articles that a tax on any import is so very likely to produce.

Before dwelling further on this point it may be well to consider the action of *export* duties. Though at present in a subordinate position they

[1] Unless the producer is able to evade the 'law of indifference.' In that case it may be for his interest to give a special low rate on imports to the taxing country.

once were of great importance, and even now the British Empire, as distinct from the United Kingdom, can show a goodly list of them. An inquiry into these taxes is facilitated by their relation to import duties. We can assume that there is a kind of symmetry in the action of both classes, so that export duties are really import ones reversed; but some little caution is needed in order to make the right comparison in each case.[1]

An export duty is, then, using this parallelism as a guide, 'a charge imposed on a commodity on its leaving a given area or nation.' The first effect will probably be to raise the price to foreign countries; whether the higher price can continue will, as with import duties, depend on demand, but on the demand of the non-taxing nations, not of the taxing one. When the foreign demand is very keen the first condition for enabling the duty to be shifted to the foreigner is present. This of itself does not suffice: the foreign consumer will, like the foreign producer in the case of imports, seek to escape paying the increased amount, and when other markets are open to him he will generally succeed. If, however, the commodity be a monopoly in the hands of one country, then, given the further condition of keen demand, it is extremely likely that the duty will be passed on to the consumer. As in the case of import duties, such instances are very rare—even India has not an absolute monopoly of opium. If a large proportion of the supply comes under the action of the tax, then, with an intense demand for the product on the part of foreigners, there will be a partial shifting of the tax, and where special markets are supplied from a single source it may be possible to throw the tax on purchasers in them up to the limit set by the cost of procuring the commodity from the next best source of supply. Substitutes free from the tax will also help to check the shifting of the duty, and they are obviously less easily stopped in the case of exports than of imports. When the export duty is not accompanied by a corresponding excise charge, the home consumer tends to gain by any limit to the rise of price, since he gets the article duty free. With regard to the incidence on producers in the exporting nation, the same questions arise as with taxes on imports. Given the usual or 'natural' state of trade, and the duty will tend to drive capital out of the production of the taxed article. Common labour and ordinary business ability will also leave this comparatively unprofitable business; but specially trained labour, the peculiar abilities of the *entrepreneur* and, in the case of extractive industries, land suited for the product, will, or at least may, obtain lower returns. It is also probable (and a like remark holds good respecting the effect of import duties) that fixed capital used for turning out the taxed article will lose some of its value. Foreign producers of the ware will, in accordance with the analogy of consumers in respect to import duties, probably gain by the increased demand at higher price, which they will, under favourable circumstances, obtain. And if there be no excise duty the home consumer will, as we have seen, so far benefit, just as special classes of home producers may gain by a protective duty.

The examination of taxation on exports, then, strengthens the belief which we had already formed from the study of import duties that the operation of all such taxes varies widely under different conditions, and this

[1] The essential point of difference is that the export duty affects a limited area of production, the import one a limited area of consumption.

result becomes superabundantly clear when we note that they may cause additional adjustments and alterations; *e.g.*, an export duty may encourage the emigration of capital which would otherwise have been profitably employed, or may prevent its immigration. The small export duty on Chinese tea is thought by some to have an injurious effect on the trade, and if China were freely open to European enterprise there can be no doubt that this charge would be an inducement to the intending tea planter to settle by preference in India. Again, protective import duties, though they may possibly encourage the investment of capital in the 'protected' industries, undoubtedly, by their effect on the scale of prices, discourage both labourers and employers from engaging in those which are not favoured and in which the cost of living is enhanced. Especially in regard to industries which produce for export does this effect appear. No one can question that, *cæteris paribus*, England is in a better position for producing for a neutral market than the United States. She has facilities for obtaining raw materials and auxiliaries of production at the lowest terms; the freedom from duty of most articles of consumption makes fairly high real wages possible along with a low cost of labour to the employer, giving so far a decided advantage over protectionist competitors.

Far more important than the special losses and gains which arise under the complex conditions of international trade is the broad general fact of the loss to the world by the hindrances imposed on exchange. Taxes on imports and on exports all imply this result. To take one of the most justifiable—the English tea duty in some degree limits the demand for that particular Eastern product. It may perhaps make tea slightly cheaper outside of England, and the British consumer might not gain the whole duty if it were remitted; but then it also checks the demand of India and China for English goods, and, so far as it falls on the Indian producer, it injures one class of British subjects. On the other hand, the Chinese export duty may give India a greater proportion of the total demand. It tends to alter the natural distribution of demand. It impedes production under what would be the most advantageous circumstances, and it may possibly slightly raise the price of tea to the consumer.

An examination of each separate import and export duty by persons conversant with the special industries affected, would show similar evils in nearly every case, though the process of tracing them out would be difficult and hard to render certain to demonstration; reasoning from general principles, supported by a large mass of evidence, quite suffices to establish the conclusion that the trade of the world is seriously hampered by the action of these taxes. We are all familiar with the gains to society from the development of the modern transport system, with the accompanying reduction in cost of carriage, but many hesitate to regard taxes on trade as being—what they really are—obstacles to the movement of commodities, and therefore hindrances to the best organisation of industrial forces. The discussion of the losses and gains which may result by the imposition or abolition of a particular duty is interesting, and such points deserve the attention of the academic economist; but these detailed and obscure questions are absolutely insignificant in their practical aspect when compared with the sacrifice which must follow from limitations on exchange. When it is urged that a nation may gain, to its neighbours' loss, by a series of dexterously arranged import and export dues, those who have no faith in such a policy are perhaps, wise in taking the contention on its

own ground, and showing what a dangerous implement such a method of taxation is, how impossible it is to foresee the direct, much more the indirect, effects of the measures adopted ; but behind and above all minor pleas of the kind lies the claim that national as well as universal interest is best promoted by freedom. Against this argument there is, so far as I can see, but one valid objection. The Governments of the world need money, and they can in no way obtain it so easily as by charging tolls on goods that enter their territories, with compensatory excise duties on those goods when produced at home. Such a course brings in revenue without causing the discontent that direct taxation must necessarily produce, and it cannot, therefore, be lightly abandoned. This plea is undoubtedly of weight ; the *revenue* import duty is in this respect clearly marked off from the *protective* one by being directed solely to the attaining of funds for the State, and in general, too, by aiming at getting those funds from the consumer. An export duty in the form of an excise, with no drawback, might, too, under the condition of the country having a 'producers' monopoly,' be defended on the same grounds ; but there is another part of the question which has to be considered, viz. : the general effect on trade by (1) its limitation, and (2) its diversion through the action of duties. The history of the reforms of English fiscal policy during the present century affords admirable illustrations. On the first point abundant evidence has been collected by Mr. Porter as to the effect of low duties in causing, or rather in not retarding, the expansion of trade and consumption ; to which we have only to add that 'no duty' is the lowest one possible, and causes no interference whatever with the natural progress of trade. The second is equally true. It is impossible to so arrange duties that they shall not more or less disturb the proportionate values of the taxed articles ; but every disturbance of values alters the force of demand, so that ill-adjusted revenue duties have this fault in common with protective taxes, that they in many cases lead the consumers to buy a less suitable article, or to abstain from that particular enjoyment ; in each case, too, depriving the State of revenue, in addition to the privation suffered by the individual.

Granting, however, the absolute necessity of customs duties at present, it does not follow that important reforms could not be introduced. We may notice a continuous movement in the direction of enlarging the areas over which fiscal systems extend ; and each enlargement implies the substitution of excise duties, or direct taxation, for import and export charges. At the commencement of the last century England, Ireland, and Scotland were separate fiscal areas ; so was each French province, each German and Italian principality. Now we have large areas, such as France, Italy, Germany, the United States, and the United Kingdom, within each of which all barriers to the movement of goods (the special case of indirect local taxation excepted) have been removed—though on their borders a dividing zone of customs is still maintained. Beside these great regions, severally capable of being in some degree self-sufficing and economically independent, there are many smaller states and economic districts with separate tax systems. Might not something be done towards fiscal grouping of the latter-mentioned, and towards fiscal uniformity in the larger states ? The British Empire affords some striking cases of tariff absurdities. Take, *e.g.*, the West Indian Islands : there are at least thirteen distinct customs areas, levying variously-graded import and export duties. West Indian planters complain bitterly of Con-

tinental sugar bounties, but say little of the export duties levied on that article in *ten* of the islands. Surely a fiscal union of the islands and a revised tariff would be an obvious boon. An Australasian customs union is a practical matter for Colonial statesmen, and it could scarcely be anything but advantageous. Still more ambitious schemes have been proposed for the union of even larger 'nations,' or groups of nations, using the latter term in its economic meaning. Such are the proposals to form a Zollverein of the British Empire, or of the North American Continent; or, again, the plan of De Molinari and Kaufmann for a customs league between France and Germany leading to a league of Central Europe. Though there is no prospect of the realisation of any of the above arrangements in the near future, yet the two latter would be economically feasible; and it may be of interest to note that the theoretical inquiry into the action of import and export duties points out elements of evil possibly resulting from their accomplishment. If the world is combined into a few great fiscal divisions, it will be much easier to use the tax system as an agent for manipulating the course of trade. A Central European or North American league would have a far more formidable power over the conditions of supply and demand than any single state could possess. Competition, both in production and consumption, would not be destroyed, but it would be limited. A smaller 'nation' which was not in any of those leagues might find itself seriously injured by the policy of its neighbours. This possible drawback notwithstanding, the general results would, by freeing trade over large territories, prove beneficial, being, in fact, the repetition on a larger scale of the removal of provincial customs barriers, which has been the work of the last two centuries.

In another direction tariff reform may be suggested, viz., in reducing the duties levied in different countries to something of uniformity. We find that now a nation taxes each article at a rate suggested solely by its own real or supposed need of revenue or 'protection.' Might not some steps be taken towards obtaining a common standard, more particularly in neighbouring countries? If the leading continental countries are determined to 'protect' agriculture, would they not at least be wise in all agreeing to charge the same duty? A customs union implies the same charge in all parts of the league's territory; and where this is not possible would not assimilation of duties be a good way of approaching it? The various standards of living and the lower position of the mass of the people in some countries than in others may be urged as an objection; but if there can be a common system of duties for Lancashire and Donegal, for Normandy and Limousin, for Westphalia and Posen, there can be no insuperable difficulty in devising a fairly uniform standard for France and Germany.[1] International prejudice is the chief obstacle, and proposals for tariff union or uniformity seem at present rather out of place; but then, 120 years ago the most sagacious and broad-minded of economists declared that to even expect perfect free trade in Great Britain was Utopian.

Practical difficulties apart, it remains true that the advantage of these

[1] There is also the obvious objection that the proportion of national income required for the use of the State is not the same in any two countries; but it is met by the equally obvious fact that direct taxation affords a ready means of supplementing any deficiency in the yield from the reformed duties on commodities—a policy which is suggested by the history of the English income tax and by the employment of direct local taxation in the United Kingdom.

reforms would be decided, as removing one of the principal hindrances to international exchange—hindrances which, moreover, affect in some degree the interests of every class, and are never so dangerous as when they are applied with the mistaken idea of advancing national welfare.

Experiments upon the Transmission of Power by Compressed Air in Paris (Popp's System).[1] *By* Professor ALEXANDER B. W. KENNEDY, *F.R.S., M.Inst.C.E.*

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THE subject of transmission of power to a distance is one of such immense importance in an industrial country like our own that I am sure I need offer no apology for bringing this paper before Section G of the British Association. In a case such as that which I have to describe to you, where the distance to which the power is to be transmitted is great enough to be measured in miles, the possible methods of transmission are not very numerous. Steam, water, air, and electricity seem to be the only four agents practically available. All four have been used to a greater or less extent, and with more or less complete success. In our own country the distribution and use of high-pressure water has been carried out with the greatest engineering skill, and with correspondingly great success, by the Hydraulic Power Company in London, and also in Hull. Electric transmission (for traction at least) has been at work on a small scale for some time in various places, and is about to be tried on a much larger scale under Mr. Greathead on the Southwark Subway. In America it has been very widely used for traction on tramways, and on the Continent it has also been used to a certain extent for power transmission for general purposes. Steam has been used on a large scale in New York, but as yet its success does not seem to be unquestionable. Compressed air has of course been used over and over again in rough and uneconomical fashion in connection with tunnelling, mining, and boring work, but I think only two practical attempts have been made to utilise it economically and on a large scale for industrial purposes. Of these two, one has been made in Birmingham and the other in Paris. The Birmingham Compressed Air Power Company has established works on a very large scale, but various causes have unfortunately combined to cause delay in the commencement of its operations, which indeed are hardly yet fairly started. In Paris, however, the transmission of power by compressed air has been in operation on a somewhat large scale and with very great mechanical success for a few years past. I have recently had occasion to spend some weeks in making experiments in connection with the Paris compressed air plant, and having been given the fullest permission to publish the results of my experiments, I have pleasure in taking this opportunity of bringing them before the members of the British Association. To avoid any misunderstanding I must premise that it is not my intention to institute any comparison between the different methods of power transmission which I have mentioned. Such a comparison, to be of any value, would require for itself a paper at least as

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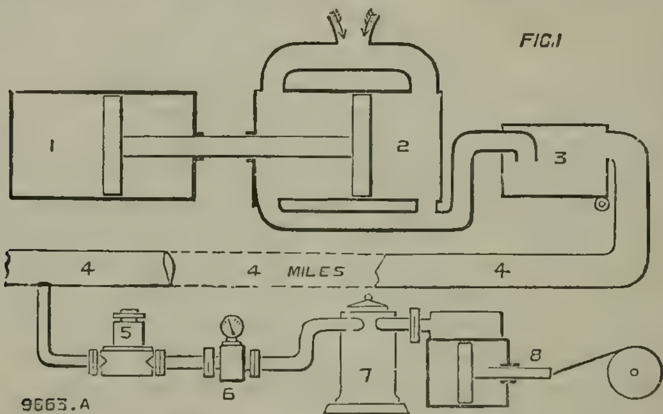
long as the one which I have to put before you, and is therefore, in the nature of things, impossible here. On this matter I wish to say only one thing, in view of a recent discussion on the Hydraulic Power Company's work in London, in which some comparisons were made between power transmission by air and by water. So far as I see, the two systems at present practically occupy different fields, and overlap but little. The work that each appears to do best is exactly that for which the other is least fitted. I see as little chance for air, just now, taking the place of water for lifts or cranes, as I do for water coming into common use in the driving of motors. I think it would be a pity if there were to be any impression that two systems were antagonistic which in point of fact rather supplement each other. Having said this much, it will, I think, be my most useful and most interesting course to limit myself to a description of the plant and methods used in Paris, and to a statement of the actual results obtained there as determined by my own experiments on the spot. The plant and methods are by no means absolutely perfect; they are not only susceptible of, but are now receiving, considerable improvements in detail in the extensions which are being carried out. In what I have to say, however, I shall confine myself entirely to results actually obtained with the present plant as it was working when I tested it two months ago, not giving it credit for the result of any of the improvements which have not yet been introduced throughout into the system of working. I shall only, after having given this statement of facts, state briefly my views as to the probable practical value of improvements which may be, or are being, carried out.

The work now carried on by the Paris Compressed Air Company has developed from very small beginnings, at first slowly, lately very fast. It originated in a pneumatic clock system, which was started about 1870, with a small 'central station' in the Rue St. Anne in the centre of Paris. This business grew gradually, until it became far too large to be carried on from such a position, and a few years since a central station, with much enlarged machinery, was established in the Rue St. Fargeau, which is in Belleville, about 4½ miles east of the Madeleine. There are now about 8,000 pneumatic clocks, public and private, in Paris, driven from St. Fargeau, and regulated by a standard clock in the Rue St. Anne; but as this part of the work, although it formed the original basis of the whole system, is now a comparatively very small part of it, and is of an entirely special nature, I do not propose to say anything further about it here. Until two years since a pair of single-cylinder horizontal engines by Farcot sufficed for the whole work; but by that time the demand for compressed air for working motors had so increased that extension had become imperative, and the present working plant of six compound condensing engines, each working two air-compressors, with the necessary complement of boilers, was put down. This plant, except the compressors, was supplied from England by Messrs. Davey, Paxman & Co., of Colchester. The compressors for the English engines were made in Switzerland on the Blanchod system. The demand for power is at present so great that at certain hours of the day practically the whole plant, old and new, indicating considerably over 2,000 horse-power, is fully at work, and in consequence a duplicate main is being laid throughout, and new engines and compressors, half of them constructed by Davey, Paxman & Co., and half by John Cockerill & Co., of Seraing, are being pushed forward as rapidly as possible.

The general system of working is illustrated roughly by the sketch diagram (Fig. 1), which of course is in no way drawn to scale, and it is as follows :—The steam cylinders (I.) compress the air to a pressure of five atmospheres (six atmospheres absolute) or thereabouts in the compressor cylinders (II.) The air is drawn in direct from the engine-house, where I found it to be about 70° Fahr., and after it has finally passed along the mains for some little distance it is again about the same temperature. It is therefore of the greatest importance to prevent its temperature rising during the compression, as all heat so taken up by the air represents work done in the steam cylinders of which no part whatever can be utilised. If the air were compressed adiabatically, *i.e.* without any cooling whatever, its temperature on leaving the compressor would be about 430° Fahr.—a temperature higher than that of saturated steam of 300 lbs. per square inch pressure. At St. Fargeau water for cooling is allowed to run into the cylinders through the suction valve during the suction stroke in such quantity that the final temperature is only 150° Fahr. So far the result is satisfactory enough ; but owing, unfortunately, to the particular way in which the cooling water is utilised mechanically, the air does not get cooled until after it has been compressed, so that practically no benefit is obtained from the cooling in spite of the extent

FIG. I



to which it occurs. The power expended, as we shall see presently, is practically equal to what would have been expended had the compression been adiabatic. The quantity of air dealt with at each revolution is 47·6 cubic feet (for the pair of double-acting compressing cylinders), which is equivalent to 3·55 lbs., the quantity of water used being about 2·4 lbs.

After compression, the air, now having an absolute pressure of six atmospheres and a temperature of 150° Fahr., is pushed into large boiler-plate receivers (III.), of which some are arranged to act as separators, and in these a large portion of the cooling water, which has been carried along mechanically by the air, is deposited and removed before the air enters the mains (IV.) The principal main is 300 mm. (11·8 in.) in diameter and about $\frac{3}{8}$ in. thick. It is of cast-iron, made in lengths perfectly plain at each end, and connected by a very simple external joint made air-tight by indiarubber packing-rings. This joint leaves the pipe quite free endwise, and also allows all necessary sideway freedom, so that accidental distortion to a quite measurable extent is entirely without effect on the tightness of the joint. The mains are partly laid under

roadways and footways as they would be in this country, and partly slung from the roof of the sewer subways. They are supplied at intervals with automatic float traps for carrying off the entrained water and the water of saturation as they deposit.

On entering a building on its way to a motor the air is first passed through a meter (V.) exactly as gas would be. The quantity passing is of course too great to allow anything like an ordinary gas meter to be used; indeed, only inferential meters seem to have been at all successful. The meter actually in use in Paris is a small double cylindrical box of external appearance as in the figure. The air passes by a branch through to the bottom of the inner box, up through it, down outside it between the two boxes, and away through a branch at the bottom opposite the inlet branch. The whole measuring-apparatus is a little four- or six-armed fan, with aluminium or nickel vanes, placed near the bottom of the inner casing, and communicating motion by a light vertical steel spindle to a clockwork register, like that of a gasmeter, placed on the top. The quantity recorded is simply the number of revolutions made by the fan, or some proportional number, and this is turned into cubic metres by multiplication by an arbitrary constant, determined by direct experiment. As to the working of this meter I shall have something to say later on; it is the only type used by the Paris company, and serves in a very large number of cases as a basis of payment.

After passing the meter the air is carried through a reducing-valve (VI.), by which the initial pressure in the motor is prevented from rising above a certain limit, which in practice appears to vary between $3\frac{1}{2}$ and $5\frac{1}{2}$ atmospheres absolute, according to the size of the motor in proportion to its work.

Between the reducing-valve (VI.) and the motor (VIII.) there is placed in all ordinary cases a small stove or heater (VII.) This heater is simply a double cylindrical box of cast iron, having an air space between its outer and its inner walls. The air under pressure traverses this space, and is compelled, by suitably arranged baffle plates, to circulate through it in such a fashion as to come into contact with its whole surface. A coke fire is lit in the interior of the stove, and the products of combustion are carried over the top of it, and made to pass downwards over its exterior surface, inside a sheet-iron casting, on their way to the chimney-flue. The heater for the motor on which I experimented (which indicated 10 to 12 horse-power) was about 21 in. in diameter and 2 ft. 9 in. high over all. The use of the heater, and the extent to which that use is advantageous and economical, are matters on which I shall touch later.

The motors themselves (VIII.) used in Paris are mainly of two types. Up to one horse-power or thereabouts small rotary engines, of a form patented by Mr. Popp, are used; into the details of these it is not necessary to enter here. They start very readily, are easily governed, are provided with capital automatic lubricators worked by compressed air, and run at a very high speed, and are altogether very convenient. They use the air with little or no expansion, without previous heating, and have, of course, no pretence to economy in use of air.

The larger-sized motors, up to double-cylinder engines 12 in. by 14 in., which is the largest size used, are simply ordinary Davey-Paxman steam-engines, employed for air absolutely without any alteration or modification. These engines have in most cases automatic cut-off gear controlled by the governor, and can therefore easily work with the largest

economical ratio of expansion for the not very high available initial pressure. I believe that in every case heaters are provided for these engines, although in some instances, where both power and refrigeration are required, they are used sparingly, or not at all, in order to take advantage of the cooling due to expansion.

After this short description of the general arrangements of the Paris company's work, I come now to the experiments which I made to ascertain its efficiency. Starting from the main engines at the central station, the particular matter which I had to determine was the indicated horse-power which would be shown by a small motor three or four miles from St. Fargeau for each indicated horse-power expended by the main engines on the air which passed through that motor. The ratio thus obtained would be the total indicated efficiency of the whole system of transmission. This ratio is in reality the product of a number of separate efficiencies, and the separate determination of these formed a necessary check on the value of the total efficiency. These separate efficiencies may be summarised as follows:—

1. Mechanical efficiency of main engines, or ratio of work done in compressors to indicated work in steam-cylinders.

2. Efficiency of compressors, or ratio of maximum work which could be done in a motor by each cubic foot of compressed air at 70° Fahr., to the work actually done in compressing that air.

3. Efficiency of mains, or ratio in which the capacity of the compressed air for doing work is reduced by friction and leakage.

4. Efficiency of reducing-valves, or ratio in which the capacity of the compressed air for doing work is reduced by the lowering of its initial pressure at the motor.

5. Indicated efficiency of motor, or ratio in which the actual indicated work done falls short of the maximum work which the quantity of air measured through the meter could do after passing the reducing-valve.

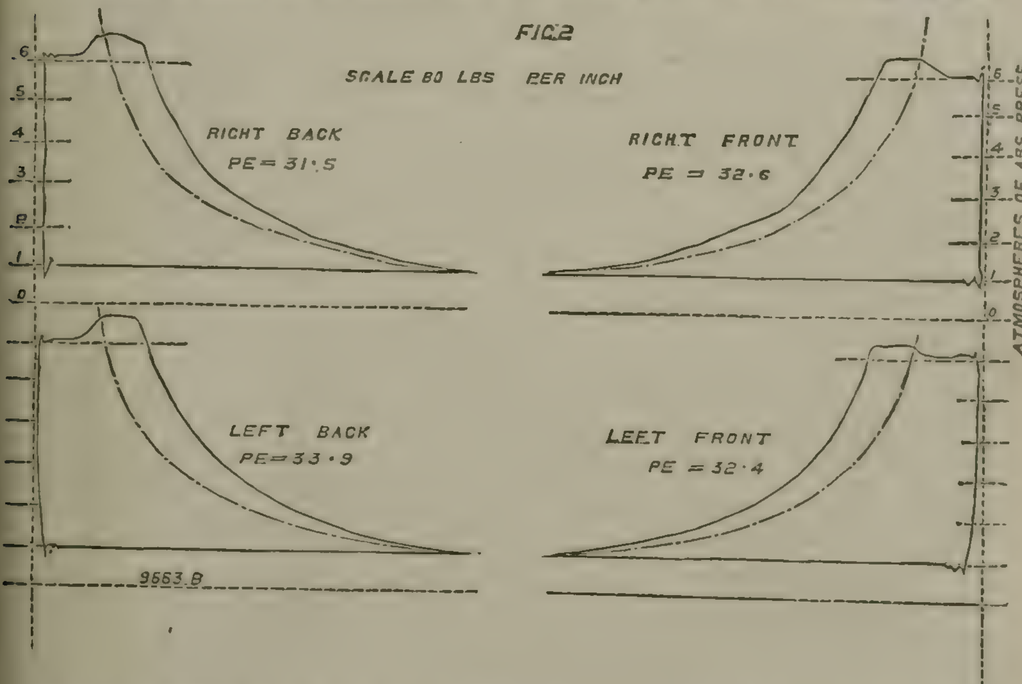
The product of these five efficiencies is the total efficiency of transmission without the use of a heater. When a heater is used the matter is somewhat more complicated. All the ratios given above represent what may be called mechanical efficiencies, all of them have *unity* for their maximum attainable value. It is therefore not possible to introduce in direct combination with them a thermodynamic efficiency (ratio of additional heat supplied to additional work done), which has for its maximum value not unity but 0·3 or some similar small value. This could only be done if the measurement of efficiency had started originally from the heat given to the steam instead of from the indicated horse-power, and this would have given numbers having a minimum of practical value or convenience. Probably the best practical measure of the efficiency of the whole transmission, when using heated air, is obtained by finding the equivalent in indicated horse-power at the central station of the coke used in the heater, and adding this to the indicated horse-power actually used. It would not be possible by the expenditure of this or any other amount of indicated horse-power at the central station to obtain the same results as by heating the air just before entering the motor; but that, of course, does not affect the question before us.

The determination of the indicated horse-power of the main engines presented no difficulty. I measured it on one pair of engines at different speeds from 21 to 44 revolutions per minute. At 31·5 revolutions per minute it amounted to 254·9, and at all speeds it was approximately 8·1

indicated horse-power per revolution per minute. The mechanical efficiency was sensibly the same at all speeds, viz. 84·5 per cent., as given in the Table. There was no method available for ascertaining to what extent the real quantity of air delivered corresponded to the nominal volume swept through by the compressor pistons. The indicator diagrams (Fig. 2) show no signs of leakage past the valve, but there are no doubt various possible leakages which would not show on the diagrams. In the absence of any direct means of determination, however, I have assumed that the compressor cylinders delivered their full volume, which corresponds to 348 cubic feet[1] of air per indicated horse-power per hour. This air has a weight of about 25 lbs. It may be pointed out that the water injected practically fills up the clearance space at the end of each stroke.

I have already pointed out that, at whatever temperature the air is delivered, it must fall to about its original temperature in the long length

FIG. 2



of mains before it reaches the motors. It is therefore a simple matter to find the maximum amount of work which can be done by the air delivered per indicated horse-power, for it simply amounts to the P V of the air at six atmospheres absolute and at 70°. Fahr. plus the work it can do in expanding adiabatically to a pressure of one atmosphere, and minus the work necessary to expel it from the cylinder at that pressure and at the corresponding temperature.[2] In the present case I find that this work is equivalent to 0·52 indicated horse-power for an hour, so that the efficiency

[1] Here and elsewhere, unless specially mentioned, volumes are supposed to be at atmospheric pressure and at 70° Fahr., the actual admission temperature during my experiments.

[2] In symbols, if suffixes 1 and 2 be used for the initial and final conditions of the air, if pressures be measured in pounds per square foot and volumes in cubic feet, the maximum work possible, without addition of heat, is—

$$(P_1V_1 - P_2V_2)\frac{\gamma}{\gamma - 1} = 3{\cdot}45(P_1V_1 - P_2V_2).$$

of the compressors is, as given in Table, 61 per cent. It will be seen from the diagrams that the compression curve falls only a little below the adiabatic, and as the area of the diagram is increased somewhat by the resistance of the discharge valve, the work done is practically the same as if the compression had been adiabatic, and there had been no cooling at all. This matter I have already referred to.

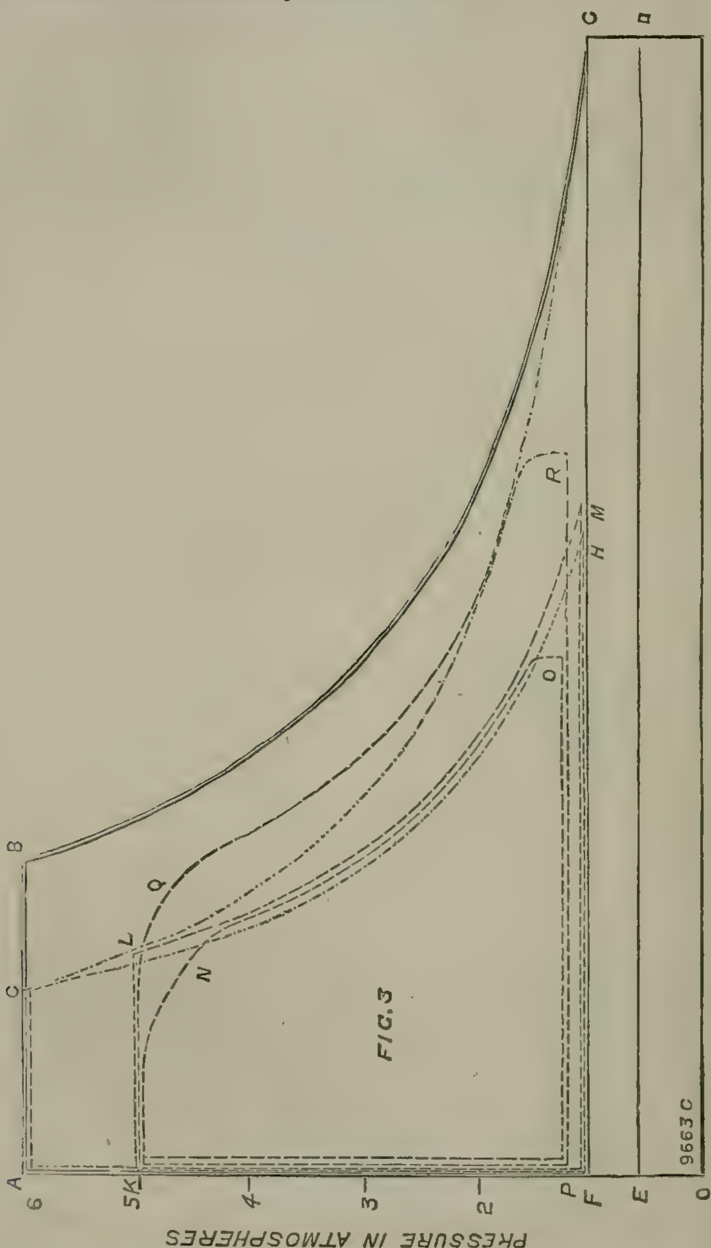


Fig. 3 shows graphically the relation between the quantities so far measured. If the area A B C D E represents on any scale the work done in the steam cylinder, the area A B C F represents on the same scale the work done on the air in the compressors. C B is an adiabatic curve, C G an hyperbola, so that A G represents the volume of the compressed air

when it has fallen in the mains to the temperature which it had initially at C. G H being again an adiabatic curve, the area A G H F (which is 61 per cent. of A B C F, and 52 per cent. of A B C D E) represents the maximum work which can be obtained from the air in a motor, the quantity calculated in the last paragraph.

If it be assumed that the temperature in the mains is constant, then any loss of pressure due to friction must be accompanied by an exactly equivalent increase of volume. Thus if (Fig. 3) the pressure falls from A to K, the volume increases from A G to K L, the point L lying on an isothermal through G. The loss of possible work due to such a reduction of pressure is represented by the difference between the areas A G H F and K L M F, in both of which the expansion curves are adiabatic. The change of temperature in passing through a reducing valve is so small that it may be assumed without sensible error that the loss due to such a process may be calculated in the same fashion.

I determined the loss of head in the mains by a series of observations made simultaneously at known points in Paris and at St. Fargeau. The pressure gauges used having been carefully compared, and all the necessary corrections made, I found the loss of pressure to vary from 0·35 to 0·25 atmosphere, according to the distance from St. Fargeau and the amount of air passing through the pipes. The average loss may be taken at 0·3 of an atmosphere at three miles from St. Fargeau, when the indicated horse-power there was about 1,250, and the maximum velocity of the air in the mains about 1,550 ft. per minute. What proportion of this loss of head may have been due to leakage, and what the amount of leakage (if any) may have been, I had no means of determining. The duplicate main to which I have referred is not yet completed, and it was impossible to isolate any portion of the mains, even temporarily, to test for leakage. From the figures I have given, as well as from the nature of the pipe joint, I cannot doubt that the leakage must, under any circumstances, have been extremely small.

In the Table I have given approximate values of the loss due to fall of pressure in the mains and through the reducing valves with various values of the total reduction of pressure. With a total reduction of half an atmosphere the combined efficiency of mains and valves is 0·96, reducing the maximum possible work at the motor to 0·5 indicated horse-power per indicated horse-power at central station. Under these conditions the minimum possible consumption of air per indicated horse-power at the motor would be twice 348, or 696 cubic feet per hour.

The motor on which I made most of my experiments was an ordinary horizontal Davey-Paxman engine with a single cylinder $8\frac{1}{4}$ in. in diameter and 12 in. stroke, fitted with automatic cut-off gear. For convenience sake I tested it at St. Fargeau and not in Paris, but I used a pressure only of $4\frac{1}{2}$ atmospheres, which pressure I found to be exceeded on branch mains $3\frac{1}{2}$ miles from St. Fargeau, where I made later experiments. The position of the motor did not, therefore, put it under any conditions different from those existing in the centre of Paris. I made a large number of experiments on this motor, under various conditions, individual experiments lasting from four hours down to half an hour. I shall here give figures representing only the four most important of my experiments, two with cold and two with heated air, averaging the two experiments in each case, so as not to burden my paper with unnecessary figures.

The motor, when indicating 9·9 horse-power, and making about 125

revolutions per minute, used 890 cubic feet of air per indicated horse-power per hour. (Its indicator diagrams are shown in Fig. 4, their area being represented by K N O in Fig. 3.) The work which this quantity of air, at the given pressure and temperature, is theoretically capable of doing behind a piston, expanding down to atmospheric pressure, is equivalent to 1·27 horse-power for an hour. The indicated efficiency of the motor (the ratio expressing loss by rounding of courses, by insufficient expansion, by back pressure, &c.) is therefore 0·79. This figure gives us a check on the ratios already worked out, for if they are right the air actually used should be $\frac{1}{0{\cdot}79}$ times as great as the 696 cubic feet already allowed for. This would be 880 cubic feet, which represents of course a most satisfactory check. It will, however, be recognised that this agreement checks the figures only so far as they apply to air actually used, and would not be vitiated or in any way affected by losses by leakage.

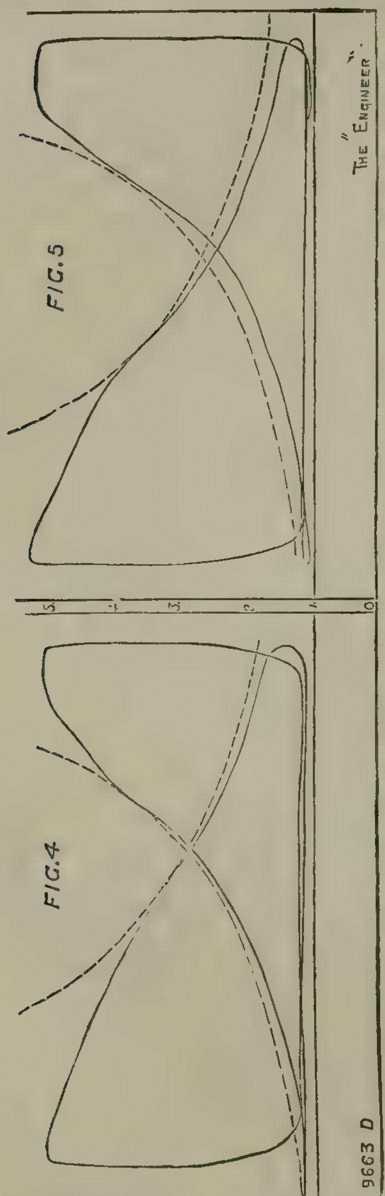


FIG. 5
FIG. 4

The vital measurement of all the experiments was, of course, that of the quantity of air used. The air was passed through one of the fan meters already described, readings of which were taken every quarter of an hour. After the experiments were over air was passed through the same meter at exactly the same pressure, and in as nearly as possible the same quantity, and then passed, at atmospheric pressure, through two large standard wet gas meters. The readings of these were taken as correct, and the multiplier for the fan meter determined from them. I found from numerous experiments on several fan meters that this multiplier varied both with pressure and with quantity, but that the latter variation was very small within the limits of my experiments. I have no doubt that the air quantities which I shall give you are correct within about 2 per cent. plus or minus.

It will be seen that the total indicated efficiency of transmission, with cold air, is 0·39 (see Table); in other words, that work requires to be done at the rate of 2·6 indicated horse-power at the central station per indicated horse-power at the motor. The motor was worked on a brake, and its mechanical efficiency was found to be 0·67, so that (see Table), in round numbers, four indicated horse-power were required at St. Fargeau per brake horse-power at the motor.

To examine the economy due to heating the air before using it, I used

the same motor, working as nearly as possible at the same power and speed, and with exactly the same pressure, but passing the air between the meter and the engine through such a heating stove as I have already described. I weighed all the coke used, and read the temperatures every five minutes during a four hours' trial. The air was heated in passing through the stove up to 315° Fahr., with a consumption of about 0·39 lb. coke per indicated horse-power per hour. As the admission temperature on the cold trials was 83° Fahr.[1] only, this corresponds to an increase of about 42 per cent. in the volume of the air, and should therefore (had the indicated efficiency remained the same) have been accompanied by a decrease of air consumption in the ratio $\frac{1}{1·42}$, or 0·70. The air actually used was 665 cubic feet per indicated horse-power per hour, which is 0·75 of the 890 cubic feet formerly required, so that the full economy is very nearly realised. The indicator diagrams are shown in Fig. 5, and are represented by K P Q O in Fig. 3. An air consumption of 665 cubic feet per indicated horse-power per hour corresponds to an indicated efficiency over the whole system of 0·52; in other words, 1·92 indicated horse-power is required at St. Fargeau per indicated horse-power at the motor. The mechanical efficiency of the motor was very much greater hot than cold, rising to 0·81. Hence about $2\frac{1}{4}$ indicated horse-power at St. Fargeau gave one brake horse-power at the motor. These figures, however, take no account of the coke burnt in the heater, and are, therefore, only to be considered as *apparent* efficiencies. Allowing for the value of the coke in the manner already described, the real indicated efficiency of the whole transmission is 0·47.

A shorter experiment with slightly higher temperatures and considerably larger indicated horse-power gave still more economical results, the air consumption falling to 623 cubic feet per indicated horse-power per hour, an "apparent" indicated efficiency of 0·56. This experiment was not, however, of sufficient duration to allow of coke measurement.

As to the value of the preliminary heating, the figures which I have given show that it caused a saving of 225 cubic feet of air per indicated horse-power per hour, at a cost to the consumer of about 0·4 lb. of coke per indicated horse-power per hour. I do not doubt that the stoking of the heater during my experiment was much more careful than it would be in ordinary practice, although, on the other hand, it would not be difficult to design a more economical stove. If, however, the coke consumption were even doubled, it would only amount to 72 lbs. per day of nine hours for 10 indicated horse-power, the value of which might be 6*d*. or 7*d*. The air saved under the same circumstances would be over 20,000 cubic feet, the cost of which, at the high rate charged in Paris, would be 7*s*. 3*d*. There is no doubt therefore that to obtain the maximum of economy the preliminary heating of the air should be carried as far as is practicable.

Of course heating the air serves the purpose also of preventing any chance of the exhaust pipe becoming ice-clogged. I found this to happen once or twice when working with cold air, its occurrence depending rather on the amount of moisture in the air than on the exhaust temperature, for the engine, after running freely with an exhaust of −35° Fahr.,

[1] This somewhat high admission temperature was the only point in which the motor at St. Fargeau differed from those in Paris, where I found the admission temperature to be from 69° to 71° Fahr.

choked later on at $+2°$ Fahr. I do not think that in any case which I met with there would have been any trouble from choking had the exhaust pipes been properly arranged. As it was, they were merely the ordinary vertical exhaust pipes of a steam engine, quite suitable for their original and for their intended purpose, but singularly unfitted for the purpose to which I was putting them.

Summarising now the whole matter as regards efficiency, it may be said that the result of my detailed investigations is to show that the compressed air transmission system in Paris is now being carried on on a large commercial scale in such a fashion that a small motor four miles away from the central station can indicate in round numbers 10 horse-power for 20 indicated horse-power at the station itself, allowing for the value of the coke used in heating the air, or for 25 indicated horse-power if the air be not heated at all. Larger motors than the one I tested (and there are a number of such in Paris) may work somewhat more, and smaller motors somewhat less, economically. The small rotary motors would of course be much less economical. The figures which I have given are, however, such as can be reached by any motor of between five and 25 indicated horse-power if worked at a fair power for its size. M. Victor Popp himself, and the engineers of the company, by no means content with the results already obtained, are experimenting in various directions with a view to greater economy, and I have not the least doubt that they will attain their end. But although I made several experiments on new apparatus, I prefer to leave their results here undiscussed, confining myself as strictly as possible to the work which has been already carried out and the economy of actual present working, rather than giving any credit for the result of improvements which, however certain, are not yet actually carried out in practical work.

A system of transmission which has actually been carried out on a large commercial scale in such a way as to have an indicated efficiency of 50 per cent. between prime mover and secondary motor, four or five miles apart, is one which needs no adventitious aids to commend it to notice, especially where its uses are so numerous and so varied, and its convenience so extremely great, as are those of compressed air. Both M. Victor Popp, who has organised and carried through the work of the Paris company, and Mr. James Paxman, who has designed and made the greater part of the machinery used, are to be heartily congratulated on the results which have attended their work.

While, however, I am unwilling to lay stress on possibilities which are not yet actualities, there can be no harm in saying that I have no doubt whatever that with mere improvement of existing methods and appliances, and without the adoption of any new or untried methods whatever, the new plant of the Paris company now being constructed can be made to have an indicated efficiency of 67 per cent. instead of 50 per cent., and to give about 0·54 effective horse-power at the motor for each indicated horse-power at the central station in the case of such a motor as that on which I experimented. Under these circumstances the air used per indicated horse-power at the motor would be 520 cubic feet, or 650 cubic feet per brake horse-power. I have the less hesitation in giving these hypothetical figures because the more important imperfections of M. Popp's transmission system arise from such a very obvious cause. Nothing indeed can be easier (as was evident on the recent visit of the Institution of Mechanical Engineers to St. Fargeau) than to

point out various weak points in the arrangements adopted; and yet, in spite of all such somewhat cheap criticism, the fact remains that no one has yet carried out a compressed air transmission with anything approaching to the same success on anything like the same scale. The fact is that the success of the system has been essentially due rather to the practical good sense with which the work has been carried through than to any special novelty in the methods employed. The air-compressing arrangements at St. Fargeau are in no respect novel or specially perfect, they had been used over and over again before; there is no special advantage in M. Popp's rotary motor that may not probably be possessed by many other rotary motors; the larger motors are simply good ordinary steam engines such as can be bought any day in open market, used without the slightest alteration. Of the fan meter it can only be said that it works well enough to allow progress to be made while it is being improved, and even of the coke stove one would not like to say very much more. The plan of heating compressed air before using it in a motor was first proposed many years ago. The great success which has attended the work in Paris has been attained because its directors have wisely chosen rather to set to work with imperfect apparatus, if only it were simple, fairly effective, and ready to hand, than to wait for the possible invention of novelties and improvements, or to risk the success of their start by the use of any unknown or untried apparatus, however promising its nature. They have had, moreover, the great advantage hitherto of being always asked for more air than they could supply, so that their works have grown and increased simply to meet a growing and increasing demand, and (fortunately perhaps) the urgency of the demand has left them no alternative but to meet it by the very simplest possible means.

I have already mentioned the great convenience and handiness which a compressed air motor possesses. From the engineer's point of view these qualities are most striking. The engine starts, for instance, without the least hesitation, even with full brake load on, directly the valve is opened, if the crank is just past the centre. This, of course, is impossible with a gas engine, and hardly less impossible with any ordinary (single-cylinder) steam engine. The absence of the heat and leakage, and of the noise and smell which so often in greater or less degree accompany the smaller steam or gas motors constitute a very much larger difference than could at first be thought possible. But from the consumer's point of view the advantages are even greater than from the engineer's. There is, first of all, the complete absence of danger and of nuisance of every kind. There is then the great saving of space, even as compared with a gas engine, and much more as compared with a steam engine and boiler. There is reduction of insurance on account of the entire absence of fire risk. Not only this, but the air motor seems to me completely to supply that most important industrial want, a motor suitable for "small industries," that is, for work carried on in workmen's own houses, or in very small workshops. For here it is not only mechanically most suitable, but in the nature of things it can be made to cool or ventilate, by its exhaust, to any desired extent. The sanitary advantage of this in cases where work is carried on in confined spaces can hardly be exaggerated. Even in a very large printing office in Paris I found an almost unbearable atmosphere made quite pleasant as long as the motor was working, by allowing a portion of the exhaust to come into the room.

By using air direct from the mains in the motor, or by heating it only very slightly, the exhaust air can be, of course, so greatly reduced in temperature as to be available for freezing purposes. In one Paris restaurant, for instance, which I visited, I found that the exhaust was carried through a brick flue into the beer cellar. In this flue the carafes were set to freeze, and large moulds of block ice were also being made for table use, while the air was still cold enough in passing away through the beer cellar to render the use of ice for cooling quite unnecessary, even in the hottest weather. The nominal function of the engine in this case was the charging of batteries used in the electric lighting of the restaurant. The conjoint use of power and cold is common in Paris, the power being in this case generally applied in electric lighting. While in any large city such as Paris it is no doubt a great point that by a compressed air system the handiest possible cooling appliances can be brought everywhere within reach, in tropical climates this is something rather of necessity than of luxury. In such cases we might have the apparent paradox of a motor worked essentially for its exhaust; the work done would be a bye-product, the cold air would be the principal thing. In such a case, if there were no useful work to be done, the motor could even be made (as has been suggested to me) to pump air back into the main, and thus virtually to about halve its air consumption. This possibility of 'laying on' cold air in hot climates is, of course, a most important matter in connection with the future of compressed air.

Most of the compressed air in Paris is used for driving motors, but the work done by these is of the most varied kind. A list which I have gives the locality, use, and power of 225 installations, nearly all motors working at from $\frac{1}{8}$ horse-power to 50 horse-power, all driven from St. Fargeau, and the great majority of them more than two miles away from it. In a number of cases (as at the Eden Theatre, Théâtre des Variétés, office of the *Petit Journal*, &c.) the motor drives dynamo machines for electric lighting. In the offices of the *Figaro* and *Petit Journal* large motors are also used for printing, and there are many small printing establishments also worked by compressed air. Among the smaller industrial purposes for which the air motors are used in Paris, I find the driving of lathes for metal and wood, of circular saws, shearing machines, drills, polishing machines, and many others. They are used also in the workshops of carpenters, joiners, and cabinet-makers, of smiths, of umbrella-makers, of collar-makers, of bookbinders, and naturally in a great many places where sewing machines are used, both by dressmakers, tailors, and shoemakers, and from the smallest to the largest scale. They find application also in all sorts of industrial work, with confectioners, coffee roasters, colour grinders, billiard-ball makers, in many departments of textile industry and other matters too numerous to mention.

TABLE.—*Summary of Efficiencies of Compressed Air Transmission at Paris,* 1889, *between the Central Station at St. Fargeau and a* 10 *horse-power motor working with pressure reduced to* $4\frac{1}{2}$ *atmospheres.*

(The figures below correspond to mean results of two experiments cold and two heated.)

1 indicated horse-power at central station gives 0·845 indicated horse-power in compressors, and corresponds to the compression of 348 cubic feet of air per hour from atmospheric pressure to 6 atmospheres absolute. (The weight of this air is about 25 lbs.)	Efficiency of main engines, 0·845.

0·845 indicated horse-power in compressors delivers as much air as will do 0·52 indicated horse-power in adiabatic expansion after it has fallen in temperature to the normal temperature of the mains.	Efficiency of compressors, $\frac{0·52}{0·845}=0·61$.
The fall of pressure in mains between central station and Paris (say 5 kilometres) reduces the possibility of work from 0·52 to 0·51 indicated horse-power.	Efficiency of transmission through mains, $\frac{0·51}{0·52}=0·98$.
The further fall of pressure through the reducing valve to $4\frac{1}{2}$ atmospheres ($5\frac{1}{2}$ atmospheres absolute) reduces the possibility of work from 0·51 to 0·50.	Efficiency of reducing valve, $\frac{0·50}{0·51}=0·98$.

The combined efficiency of the mains and reducing valve, between 5 and $4\frac{1}{2}$ atmospheres, is thus $0·98 \times 0·98 = 0·96$. If the reduction had been to 4, $3\frac{1}{2}$, or 3 atmospheres the corresponding efficiencies would have been 0·93, 0·89, and 0·85 respectively.

Incomplete expansion, wire-drawing, and other such causes reduce the actual indicated horse-power of the motor from 0·50 to 0·39.	Indicated efficiency of motor, $\frac{0·39}{0·50}=0·78$.
	Indicated efficiency of whole process with cold air, 0·39.
By heating the air before it enters the motor to about 320° Fahr., the actual indicated horse-power at the motor is, however, increased to 0·54. The ratio of gain by heating the air is, therefore, $\frac{0·54}{0·39}=1·38$.	Apparent indicated efficiency of whole process with heated air, 0·54.
In this process additional heat is supplied by the combustion of about 0·39 lb. coke per indicated horse-power per hour, and if this be taken into account the real indicated efficiency of the whole process becomes 0·47 instead of 0·54.	Real indicated efficiency of whole process with heated air, 0·47.
Working with cold air the work spent in driving the motor itself reduces the available horse-power from 0·39 to 0·26.	Mechanical efficiency of motor, cold, 0·67.
Working with heated air the work spent in driving the motor itself reduces the available horse-power from 0·54 to 0·44.	Mechanical efficiency of motor, hot, 0·81.

One particular instance of variety of application which interested me much I may mention. At the 'Montagnes Russes' I found a large horizontal engine placed in a recess driving a dynamo and cells for the electric lighting of the whole building; a small vertical engine in another place worked the rotary pump, which actuated the 'cascade;' two or three large air-driven fans in wooden shafts served for ventilation; and lastly, a simple connection on a flexible pipe threw the air pressure into the beer barrels as they were brought in, and transferred their contents to a height from which they could afterwards descend by gravity to the place where they were required.

As to the rate at which the compressed air is sold, I believe that in most of the larger installations the work is done by contract (at so much per lamp-hour in the case of the electric lighting), but in the smaller ones the air is charged for by meter. The rate of charge is 1·5 centime per cubic metre for air used in motors and 2 centimes per cubic metre for air used directly. Air used for raising fluids is charged according to quantity raised. The former rate is equivalent to 4·25*d*. per 1,000 cubic feet (the volume in all cases being measured at atmospheric pressure). In addition to this a fixed charge of from 100 to 250 francs is made for pipes and connections, and a small rent for the motor if it be not bought outright, or by twenty-four monthly instalments.

In conclusion I have to express my thanks to M. Victor Popp and to the directors and officials of the Paris Compressed Air Company for not only giving me permission to make the experiments of which I have laid some results before you, but also for taking much trouble to afford me every facility for making a thorough investigation of the matter upon the lines which I had myself laid down as those along which I proposed to work. I think it is not too much to say that as the result of this I have had the good fortune to be able to make a more detailed and complete evaluation of all the efficiencies which together make (or mar) the efficiency of a complete transmission system than has ever been made before. I shall be very glad if my experiments prove in any way useful to those who in future may have to do with the carrying out of power transmission by compressed air in this country or elsewhere.

The Comtist Criticism of Economic Science.
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[A communication ordered to be printed *in extenso* among the Reports.]

I. Conflicting Opinions and Possible Reconciliation.

II. Types of Economic Organism: the Family, Village, City, Nation.
   1. Later Types most effective and important.
   2. Early Types as survivals.
   3. The Economic Man relative to the Organism.

III. Economic Conceptions, formed by reflection on Economic Phenomena.
   1. The Importance of Definition.
   2. Economic History as propædeutic to Political Economy.

IV. The Investigation of Economic Phenomena.
   1. Accurate Description.
   2. Explanation.
      (*a*) Difficulty of Interpretation.
      (*b*) Free Competition assumed for the purposes of Investigation.

I.

THAT political economy has fallen somewhat into discredit in recent years is a fact which must be admitted, and which we shall do well to face. Perhaps it may be partly due to the disputes among leading economists as to the scope of the study; each professes to provide the genuine article, and issues warnings against the exponents of science falsely so called. If we look to the two ancient Universities, we find that Oxford declares that the Ricardian economist has 'constantly exalted into the domain of natural law what is after all and at the best a very dubious tendency, and may be a perfectly baseless hypothesis';[1] while Cambridge exposes the mistakes which have been made by the 'extreme wing[2] of the modern real or historic school of economists,' and asserts that the 'most reckless and treacherous of all theorists is he who professes to let facts and figures speak for themselves.'[3] If we turn to the dicta of the accredited repre-

[1] Thorold Rogers, *Economic Interpretation*, 7.
[2] Marshall, *Present Position*, 39.
[3] *Ibid.*, 44. At Professor Marshall's request, I give the sentence in full. 'Experience in controversies such as these brings out the impossibility of learning anything from facts till they are examined and interpreted by reason; and teaches that the

sentatives of the study who have presided over Section F, we may remember that conflicting utterances have been heard in different years. At Dublin much was said of the 'narrowness' and 'vicious abstraction' of the 'dominant school of political economy,' and a fear was expressed that the study would cease to gain attention unless it was 'subsumed under and absorbed into sociology.'[1] At Aberdeen, however, rival sociologists were introduced to make sport before the Section by their 'portentous disagreement,' and we were admonished to follow the steps of the 'English economists who maintain the tradition of Adam Smith and Ricardo,'[2] and to continue 'that labour of reflective analysis by which our conception of fundamental economic facts has grown continually fuller and more exact.' It is not a matter for surprise that the plain man should be tempted to ask whether the study as at present pursued is more than a jumble of conflicting opinions; for such economic scepticism there is ample excuse. At the same time I cannot but feel that this contemptuous disregard arises from a too hasty judgment on a study of great and ever-increasing importance. To my mind, each of the modes of treatment which opponents advocate has a real place in the thorough investigation of economic phenomena. The mere fact that different teachers have adopted such different standpoints only serves to show us the vast range of the subject, when once we come to feel that the different modes of treatment and statement do not necessarily conflict, but may really serve to supplement one another. It will be my endeavour to show that there are elements of truth in each view, and that therefore a reconciliation is possible; though I cannot profess to restate each opinion within such limits that it shall be clearly compatible with all the rest; to do so would be to render the reconciliation complete. I shall only insist that each of the conflicting views is important, and must be taken into account if our investigations are to be exhaustive; but I shall not attempt to show *how far* each is true.

Even before the repeal of the Corn Laws had crowned the efforts and added to the reputation of the Manchester school, the question of the adequacy of their treatment of social problems had been raised through the wider views of human society which were propounded by Hegel,[3] and in a more aggressive form by Comte.[4] The Comtist criticism called forth a reply from J. S. Mill,[5] which has been re-echoed, as if it had been conclusive.[6] So far from driving the Comtists from the field, however, it has not prevented them from assuming leading positions. The recent article in the 'Encyclopædia Britannica' was avowedly written from this standpoint,[7] and when Professor Thorold Rogers inveighs against political economy as a 'crude metaphysic'[8] which is 'strangling itself with definitions,'[9] he seems to be re-echoing the language of Comte. If we review his general attitude—for I do not propose to enter into detailed

most reckless and treacherous of all theorists is he who professes to let facts and figures speak for themselves, who keeps in the background the part he has played, perhaps unconsciously, in selecting and grouping them, and in suggesting the argument, *post hoc ergo propter hoc*.'

[1] *Report of British Association*, 1878, pp. 644, 648.
[2] *Ibid.*, 1885, pp. 1148, 1150.
[3] Comp. J. H. Stirling, *Secret of Hegel*, ii. 541.
[4] Comte, *Philos. Positive* (1839), iv. 264.
[5] *Auguste Comte*, 80.
[6] Marshall, *Present Position*, 36.
[7] Ingram, *History of Political Economy*, 5, 240.
[8] *Economic Interpretation*, 2.
[9] *Ibid.* viii.

and verbal criticism—we shall perhaps come to hope that each of the rival schools of economists may furnish a contribution which is a real aid to the advance of the study.

II.

Human beings are forced to devote conscious efforts to the maintenance and perpetuation of human life; food, clothing, and shelter all subserve this final end, and the conscious efforts for this end which have been made by human beings, under different physical conditions, and in different stages of culture, supply the phenomena which the economist has to investigate.

In attempting to indicate a principle of arrangement by which this vast mass of information may be tentatively grouped for our present purpose, I fear I must discard the instance which has exercised such a fatal fascination on many minds; I shall leave Robinson Crusoe out of account, and consider man, not as an isolated being, but as part of an organised society. We may then note several social groups of different types, each of which has been usually regulated as a whole for economic purposes, and which may therefore be taken as distinct economic organisms.

A. The simplest of these is the *family*, whether in its early condition as alluded to in the accounts of the patriarchs in Genesis, or when elaborately regulated, like the villas of Charles the Great.[1]

B. Again we have the *village community* as it has been described by von Maurer, Sir Henry Maine, and others.

C. Further, we may have the *municipal* organisation of Greek cities or mediæval towns, where citizenship gave a man a place in industrial and commercial life: there were minor associations of artisans or dealers; but besides all these there was a living unity, for economic purposes, in the town as a whole.

D. There are also cases where the *nation* is an economic whole: we may have a great legislative body, like Parliament, which controls the industrial and commercial life of a country; in such a case the commercial rivalries will not be with other villages or other municipalities, but with other countries. Our struggle with the Dutch in the seventeenth century is a case in point.

E. We even have the beginnings of international agreements which aspire to embrace the whole world; postal arrangements afford one illustration, and bimetallists hope to furnish another. The economic importance of such cosmopolitan organisations and their bearing on national industry do not appear to me to have attracted the attention they deserve.

1. If we for a moment compare these distinct types of economic organism, we may certainly say that those which are mentioned later are far more *effective* for their purpose than the earlier ones. The simplest tests of efficiency are (1) the amount and character of the building done, since it shows how much social energy can be diverted from supplying immediate wants to the work of providing permanent improvements; (2) the success in securing the necessaries of human life as evidenced by the numbers of the population and the death-rate. Tried by these tests, there can be no question as to the superiority of the larger and more complex organisms: the patriarchal family drew its food-supply from a

[1] Capitulary *de villis.* Pertz, *Monumenta Germania*, iii., 184.

very limited area, and was exposed to risks of famine which do not threaten a nation with world-wide commerce; they had but little skill in clothing, and had not such a variety of fabrics for different seasons as we possess. The contrast in the buildings erected brings out still more plainly our extraordinary advance in control over industrial forces. The argument in regard to mediæval life is as sound if not so obvious; suffice it to say that a great queen in a royal hall in Norman times, with no carpets, no flooring, no bed to sleep on, and no plates to eat off,[1] was not nearly so well provided with the material conditions for a healthy life as the nineteenth-century pauper. The English economic organism of the present day is far more effective for the maintenance and perpetuation of human life than groups of the family, village, or municipal type; and just because it fulfils its purpose better, the modern economic organism has superseded and is everywhere superseding less effective institutions in the struggle for existence.

2. Even when the earlier types are superseded they must not be ignored, for they continue to exercise an important influence as survivals within the larger groups. Thus the family served as the sphere for technical education in weaving in England long after a term of apprenticeship had been enforced by Parliament.[2] For good, and sometimes for evil, the old social structures are embedded in modern institutions, and English society is complicated, partly because it carries on such large and various industry and commerce, and partly because it embraces so many historical survivals.

Nor is this only the case in old countries. The United States of America are little more than a century old, and society was deliberately constituted in accordance with modern principles; yet even in their territories there are curious remnants of township and manorial institutions[3] which were imported from England, and special features distinguish the districts which have been peopled by Irish, French, or German settlers.

If this is true of each of the more advanced societies, it is also true that if we view the world as a whole we shall find all the various economic types existing side by side. Even if we take a mere portion of a continent, like our Indian Empire, we may see traces of them all in active work—undivided joint families and village communities; vigorous towns like Ahmedabad, with its gilds—and the British Raj controlling all, with a keen regard for the collection of revenue, and half a thought for the opium trade with China, and the prosperity of Lancashire in the background.

Whatever economic problem has to be faced in England, in the United States, or in India, or in connection with their relations to one another, we must take the special sociological conditions into account. Economic 'generalisations must necessarily be relative to a given form of civilisation and a given stage of social development. This,' according to Mr. J. S. Mill, 'is what no political economist would deny.'[4] But some of them

[1] Turner, *Domestic Architecture*, 97–104.

[2] 5 El. c. 4.

[3] *Johns Hopkins Political Studies*, II.

[4] *Auguste Comte and Positivism*, p. 81. He apparently holds that the generalisations hold good, but that it is always necessary to add those qualifications which are required to adapt our statements to the circumstances of other peoples. I should prefer to say that it is only in the case of peoples in a similar stage of civilisation that this mode of adjustment proves convenient. If a great deal of correction has

at least have appeared at times to forget it, and we have to thank the Comtist criticism for forcing us to remember that the material truth of economic principles depends on complicated social conditions, and that they have no independent validity.

3. It is quite as important to bear this in mind if we are discussing, not the wealth of nations, but the economic conduct of an individual; his habits and ideas and aspirations are formed by the society in which he lives; the economic man of each time and place is relative to the economic organism of which he forms a part. Partly by custom, partly through explicit regulation, he will have to do as the society around him does—to work their hours, and use their holidays, and buy and sell on their terms, be they by calculated or competition prices. As a matter of fact, in the more complicated societies there is less repression of the individual's independent action; and it is also true that his positive aims are deeply affected by his social environment. In India the individual desires to be respected in his caste, as in mediæval towns [1] the individual wished to stand well with the good men of his craft, or to hold office and attain to civic dignity,—not so much to be rich himself as to stand well with his neighbours in a prosperous community. In modern life the individual wishes, not to stand well in his class, but to rise out of his class to a better social grade; and since wealth gives the means of gratifying that ambition, the desire of wealth has become a dominant factor in the minds of most men. Thus the 'economic man' is not a constant type, but he is always relative to his social environment, both as concerns his habits and his ambitions. As Professor Thorold Rogers excellently says, 'much which popular economists believe to be natural is highly artificial.' [2] Even those who do not see much hope of constructing a systematic science of society may hold that little progress can be made in investigating the economics either of national or individual life unless careful account is constantly taken of the special social conditions at every point.

III.

The changes in the subject-matter of economic investigation, as the more effective organisms superseded others, have been necessarily followed by changes in economic terminology and in economic conceptions. As always in the growth of knowledge, there has been progress from the vague to the definite. Men have found better means of supplying their wants, partly by mechanical inventions and physical discoveries, partly by introducing better forms of the combination and division of labour. Along with this greater complexity in the organism, there has been the need of new names to describe its various parts, and the opportunity for more careful reflection on their several functions. Knowledge could not advance until the things to be known came into being; it was quite impossible for anyone to understand the principles which, as we say, determine the rent of arable land, in a village community where no corn

to be introduced, it may be simpler to state the principles which hold good for, *e.g.*, a village community, in an entirely different shape, rather than try to adapt generalisations drawn from modern society. Mr. Mill would apparently agree that we could not adapt our economic generalisations, but he seems to hold that the phenomena of primitive life lie outside the scope of economic science altogether.

[1] Riehl, *Deutsche Arbeit*, 21.

[2] *Economic Interpretation*, p. vi.

was taken to market, or during the sixteenth century, when the competition value of land was determined by its capability for rearing sheep and supplying wool. It was not till the eighteenth century that English agriculture took the form which Ricardo's law assumes, and his theory of rent could not have been recognised and stated till the facts which he explains became patent. In criticising Adam Smith's doctrine of rent[1] we ought to consider more than we do how far it applied to the facts he had before him.

Primitive industry and commerce are very simple: there is very little division of employment and very little specialisation of function, and therefore very little can be known or accurately stated about the increase of wealth. The villan of 'Domesday Book,' who had a holding and owned a yoke of oxen, and was bound to work two days a week on the domain, could not distinguish between his wages and the reward of his capital, or specify the rent for which his farm would let. The merchants of Venice had shares in ships and would buy or sell such property, but they knew little of contango or backwardation. It is only in modern society that these different things exist in clearly marked forms so that it is possible to distinguish them accurately and have a definite terminology. And hence it follows that the economic phenomena of modern society repay study far more than those of any earlier condition. Not only is the modern economic organism most effective, and therefore best worth attention, but it is most complicated and gives us the best opportunity of discriminating different functions, and even by means of statistics of measuring our results with some degree of precision. Till the working of the economic organism was fairly understood it was impossible to collect or tabulate statistics that should show the rate at which changes of real importance were progressing; accurate measurement only becomes of interest when we know what it is worth while to measure. Hence a great part of the figures in the 'British Merchant,' or in Playfair's 'Commercial Atlas,' which exhibit changes in the balance of trade between England and various countries, are of little use to modern economists. It is only in modern times that sound analysis and accurate measurement of economic phenomena have become possible.

1. The view which has just been stated as to the possibility of continued growth in the accuracy of economic knowledge is obviously opposed to the Comtist criticism of the followers of Adam Smith. He complains of the barrenness of their discussions and the idle logomachies in which they indulged; but time is not wasted that is spent in clearing our conceptions and securing a good definition of terms we commonly use. Especially is this the case when, as in economic science, disputes about definitions are really disputes, not about words, but about things.[2] As Dr. Whewell said,[3] in language which was quoted with approval by Mill, 'There is a tacit assumption of some proposition which is to be expressed by means of the definition, and which gives it its importance. . . . Definition may be the best mode of explaining our conception, but that which alone makes it worth while to explain it in any mode is the opportunity of using it in the expression of truth. When a definition is propounded to

[1] *Wealth of Nations*, Bk I., xi. Dr. Anderson was able, however, to observe the phenomena in Scotland, and to formulate this principle in his *Enquiry into the Nature of the Corn Laws* (1777).

[2] Mill, *Logic*, IV. 4.

[3] *Novum Organum Renovatum*, 35–40.

us as a useful step in knowledge we are always entitled to ask what principle it serves to enunciate. . . . When it has been clearly seen what ought to be our definition, it must be pretty well known what truth we have to state. The definition as well as the discovery supposes a decided step in our knowledge to have been made. The writers on logic in the Middle Ages made definition the last stage in the progress of knowledge, and in this arrangement at least the history of science and the philosophy derived from the history confirm their speculative views.'

Thus Ricardo's doctrine as to the meaning of economic rent was not mere verbiage, but the statement of a truth which had been acted on but not explicitly recognised.

Comte's jealousy of the irregular pursuit of knowledge[1] led him more than once to adopt an attitude which many of his followers have been forced to repudiate; busy as he was in the systematisation of knowledge, he did not sufficiently allow for its farther progress. In this way he had little sympathy with those who were pushing their investigations farther in special branches of knowledge; besides, he apparently did not see that careful definition was a necessary condition for further progress in economic science. But anyone who has been forced to study the pamphlet literature of the seventeenth and eighteenth centuries must have felt how often brilliant men went astray for want of more accurate economic analysis. The argument between Locke and Lowndes about money and recoinage would have gained immensely in clearness if they had better understood the nature of—that is, if they had had a definition of—cost of production and had seen how the cost of production affected the exchange value of the precious metals. While we may hold with Comte that the underlying sociological conditions are of the first importance in discussing any economic problem, we may also hold that clear conceptions and accurate analysis are necessary too; and may feel that Malthus, and Ricardo, and Jevons, not to mention the living economists at Cambridge, who are ably carrying on their work, have made contributions to the progress of economic knowledge which are of the first importance, and which we should be foolish to slight.

2. Another remark, which raises a side-issue, is not perhaps inappropriate here; anyone who has been engaged in teaching the elements of economic science must have found himself embarrassed by the complexity of modern society, and the difficulty of finding simple instances to illustrate the principles laid down. Hence economists are driven to draw on their imagination for examples. Who does not know of the man on Lake Superior with a musical box; and the other who gave over eating pineapples and paid men to dig him a fish-pond; and how the Germans tried to buy tons of iron with yards of linen? They are as familiar as Robinson Crusoe saving his corn to be capital, or Balbus building a wall. The teaching of political economy would gain immensely if we could get rid of these puerilities, and draw real instances from actual life; and these we can find in abundance if we will be content to seek them in earlier and less complicated states of society, when industry and commerce really were much simpler. Economic history is the best propædeutic to political economy. The sumptuary legislation of bygone days explains the evils of unproductive consumption; the story of the debasement of the (French) currency in the fourteenth century gives now, as it did to

[1] *Politique Positive*, i. 337.

Nicholas Oresme, the clearest, because the simplest, illustrations of the accruing evils; the difficult problems of foreign trade and the foreign exchanges were set in their simplest forms when English trade was forced into narrow channels, and consisted chiefly of the export of wool and import of wine. Modern society is the field to which the advanced student will be attracted in the hope of carrying our knowledge farther by his investigations, but the simpler transactions of early times afford a field where the beginner can find instruction, not from abstract principles and fancy illustrations, but in the phenomena of actual life.

IV.

To return to M. Comte: there is another dictum of his to which I must allude, though I shall be forced to trench on dangerous ground. The President last year referred to it, and dismissed it with the scorn he felt justified in bestowing on something which, as he said, he did not understand.[1] Comte denied to political economy an independent place in the hierarchy of science. This is a hard saying, especially here, since the frequenters of Section F are always nervously anxious to maintain that their science is as good a science as any other, and better too. But, after all, Comte never disparaged the importance of the economic and industrial analysis of society: his dictum referred to his own classification of the principal departments of knowledge. Other branches of learning share a similar fate. Theology, which some of us regard as the *scientia scientiarum*, has no place in his scheme; geography, and geology, and anthropology, and mechanical engineering are not included in the list; Sections C, and E, and G, and H share the fate of F. But though political economy is not treated as a science in this classification, it may still be regarded as a study which deals with an important group of social phenomena, and which may certainly deal with them in a scientific fashion. For the progress of this study two distinct processes are required, as in the case of all other empirical sciences—the accurate description and the subsequent explanation of phenomena.

1. Economists have not always recognised the great importance and difficulty of the work of description; it is specially requisite in order that we may pay proper attention to the earlier economic organisms which are found among primitive peoples, or estimate their actual importance so far as they survive among ourselves. It is in this way that account may be taken—and the more methodically the better—of the sociological considerations which underlie any economic problem; it is merely idle to excuse ourselves from putting them in the foreground because sociological laws are not yet formulated and the information has not been satisfactorily systematised. Whether formulated or not, the sociology of each country must be examined before the economic problems it presents can be attacked. Mr. Mill justifies his attitude in ignoring early and surviving economic forms by saying that it is only through 'the principle of competition that political economy has any pretensions to be called a science';[2] and he thus excludes a vast mass of economic phenomena from the sphere of scientific investigation. Professor Marshall, instead of accepting the description of mediæval or Indian economic forms as they actually occur,

[1] *Report of British Association*, 1888, p. 749.
[2] *Political Economy*, II. iv. 1, 2.

sets himself to show that the accounts of them can be so arranged and stated as to afford illustrations of Ricardo's law of rent.[1] This intellectual exercise can be best paralleled from the works of Alexandrian writers in the 'theological stage,' who ignored the Old Testament as a record of actual life, but forced it to yield illustrations of universal and spiritual truths.[2] The accurate description of early economic organisms is necessary that we may understand the development of modern forms, and the nature of survivals in modern times; economic history is not merely to be treated as a field from which we can cull additional illustrations of universal truths—if we want them; but the study may enable us to understand actual life both in the past and the present. So long as economists are prepared to exclude a large range of phenomena from consideration, or take pains to represent the transactions of mediæval life in such a shape that they shall appear conformable to modern practice, they may expect to be charged with a 'disregard for facts.'[3]

2. The explanation of observed facts must be a matter of great difficulty; they never speak for themselves. We must interpret them, and the economic facts of the past can only be interpreted in the light of the moral and intellectual conditions of life in the past, not by the mere intuitions of an intelligence formed by a nineteenth-century education. The more the contradictions and inconsistencies of various writers of the historical school are exposed,[4] the more will they be forced to pay attention to method, and to lay down a sound method of procedure, which will approve itself by yielding similar results in the hands of all investigators, and not leave us to trust to the personal intelligence of each.

But for the explanation of facts in modern times we do possess such a method; the process of explaining the facts of modern economic life can be carried farther by the use of an hypothesis. In our complicated society we are able to isolate certain phenomena artificially so as to examine the causes which are at work. With this view we may assume

[1] *Present Position*, 49. As I was sorry to learn that Professor Marshall considered himself aggrieved by the criticism contained in this sentence, I offered to introduce any disclaimer he might send. I gladly append what he has forwarded me.

Professor Marshall asks me to say that the references which I have made to him imply that he takes a position with regard to the historical school of economists different from that which he does take, and that he considers the most important remarks he made about them in the *Present Position of Economics* were in the following passage (p. 39):—'It would be difficult to overrate the importance of the work that has been done by the great leaders of this school in tracing the history of economic habits and institutions. It is one of the chief achievements of our age, and is an addition of the highest value to the wealth of the world. It has done more than anything else to broaden our ideas, to increase our knowledge of ourselves, and to help us to understand the central plan, as it were, of the Divine Government of the world.' He desires me to add that, 'in his opinion, Mediæval and Indian land tenure systems are of great interest from many points of view, and that the study of the relations in which they stand to the Ricardian theory is an essential part, but only a small part of the duty of the economist in regard to them.' The last sentence gives a little fresh light on Professor Marshall's view. His lecture had spoken disparagingly of members of the historic school, and was silent as to any part they might take in the prospective advance of the study; while the sentences which express enthusiastic admiration for what the 'great leaders' have done, do not really mitigate the severity of the judgment on the rank and file of the school. I trust that the explanation now given may correct any misapprehension which has gone abroad.

[2] Compare the γνῶσις τριῶν γραμμάτων in *Ep. Barnabas*, ix.

[3] *Economic Interpretation*, vi.

[4] Marshall, *Present Position*, 39–47.

the existence of perfectly free competition, and trace out what tends to happen in some particular case on this supposition. This is the form which our *investigations* must necessarily take; but it is one which may be discarded as soon as we have reached definite *results in regard to actual society.* The statement of what tends to happen under the conditions of free competition affords an admirable instrument of scientific investigation for modern society; but economists sometimes seem to insist that it is also a body of established truth about human society in general. It was when the methods of economic analysis were thus hypostatised into a body of dogmatic truth that Comte felt justified in condemning the 'pretended science' as merely 'metaphysical,' or, as I should prefer to say, 'transcendent,' since it parts company with actual experience and becomes a body of empty and formal statements. That economic truths would hold good in a planet where there was no wealth is an ingenious speculation, even if it does appear somewhat 'trivial';[1] but a truth which is so empty that it applies everywhere, can carry us but a little way in the explanation of actual phenomena anywhere. When we discuss the definitions of economic terms, not as the means of embodying new knowledge and improving our instrument of investigation, but as a mode of stating universal truths which have a mysterious 'reality' altogether apart from mundane phenomena, we are in danger of falling back into the 'metaphysical' stage of intellectual life in which scholastic science flourished.

Perhaps one might summarise this criticism of Comte's attitude towards economic science by quoting a favourite phrase of Professor Maurice's, and saying that he was right in what he asserted and wrong in what he denied. If we cherish a hope for the further progress of special science, and especially for advance in economic study, we shall wish to investigate the whole range of economic phenomena, and to attach full importance to the sociological conditions which underlie them; but we shall also welcome additional truth, when embodied in better definitions, as an improvement in our instruments for investigating the phenomena of modern life.

On the Advisability of assigning Marks for Bodily Efficiency in the Examination of Candidates for the Public Services. By FRANCIS GALTON, *F.R.S.*

[*The following communications to the Anthropological Section were ordered by the General Committee of the* BRITISH ASSOCIATION, *to be printed* in extenso *among the Reports.*]

AN important paragraph occurs in the recently issued report of H.M. Civil Service Commissioners (xxxiii. p. 15). It runs as follows:—

'It was thought advisable, some years ago, to consider the possibility of making physical qualifications an element in the competitions for entrance into Woolwich and Sandhurst, and a joint Committee of this Department and the War Office drew up a scheme of competition which seemed easy of application. Circumstances caused it to be laid aside at the time, but on our recently bringing it again under the notice of the

[1] Marshall, *Present Position*, 24.

War Office we were informed that the military authorities did not think it necessary to introduce such a competition, being completely satisfied with the physique of the young men who came to them through our examinations. At the same time we may state that should any department in the public service be desirous of testing the physical qualifications of its officers more severely than at present, we anticipate that there would be no more difficulty in determining the relative capacities of the individual candidates in this respect than is experienced in the literary examination. Moreover, encouragement would be given generally to candidates to maintain a good state of health while preparing for the literary examinations, and any tendency to over-pressure would thereby be diminished.'

It is not easy to imagine a topic more suitable for the notice of the Anthropological Section than that which is suggested by these remarks. Anthropologists peculiarly concern themselves with the practice of human measurements, and with determining the most appropriate ways of discussing them. They occupy themselves with defining the bodily efficiency of individuals and of races, and in devising tests that shall give warning whenever growth and development are not proceeding normally. The curious and hardly accountable disregard of bodily efficiency in those examinations through which youths are selected to fill posts in which exceptional bodily gifts happen to be peculiarly desirable, must strike the attention of anthropologists with especial force, and they of all persons are best able to appreciate how much is sacrificed by its neglect.

What has just been said has no reference whatever to the pass-examinations now made by medical men in order to eliminate candidates who are absolutely unfit. The necessity for such pass-examinations is obvious. The reform now asked for is to give additional marks to those youths who, being fit for service, are at the same time exceptionally well fit so far as bodily efficiency is concerned.

If the opinion of the military authorities quoted above be interpreted to mean that literary examinations are indirect tests of bodily efficiency, that view can be now shown to be erroneous. There has been a vast amount of lax assertion in reference to this matter, some having said that high intellect is often associated with a stunted and weakly frame, and others having pointed to instances in which high mental and high physical powers were connected; but it is only very recently that we have secured a firm and sufficiently large basis of facts for trustworthy conclusions. These are the various measures of Cambridge students made during the last two or three years, and discussed by Dr. Venn, F.R.S., in an excellent memoir recently published in the Journal of the Anthropological Institute. The number of those who were measured is 1,905, and they were divided into three classes—(1) high honour men, (2) low honour men, and (3) poll men (that is to say, those who did not compete for honours but took an ordinary pass degree). The result was that the physical efficiency of the three classes proved to be almost exactly the same, except that there appeared to be a slight deficiency in eyesight among the high honour men. Otherwise they were alike throughout; alike in their average bodily efficiency, and alike in the frequency with which different degrees of bodily efficiency were distributed among them. Therefore the fact that a man had succeeded in a literary examination does not give the slightest clue to the character of his physical powers, and an opinion that the present literary examinations are indirect tests of bodily efficiency must be considered erroneous.

The intellectual differences are usually small between the candidates who are placed, according to the present literary examinations, near to the dividing line between success and failure. But their physical differences are, as we have just seen, as great as among an equal number of the other candidates taken at random. It seems then to be most reasonable whenever two candidates are almost on a par intellectually, though one is far superior physically, that the latter should be preferred. This is practically all I propose. I advocate no more at present than the introduction of new marks on a very moderate scale, sufficient to save from failure a few very vigorous candidates for the Army, Navy, Indian Civil Service, and certain other Government appointments in which high bodily powers are of service. I would give the places to them that would be occupied under the present system by men who are far their inferiors physically, and very little their superiors intellectually. I am sure that every successful employer of men would assign at least as much weight as this to bodily efficiency, even among the highest class of those whom he employs, and that Government appointments would be still better adjudged than they now are if considerations of high bodily efficiency were taken into some account.

It is scarcely necessary to press my own views in detail as to the particular tests most easily available, several of which I actually employ at my own laboratory at South Kensington. They would include the well-known measures of strength, breathing capacity, agility or promptness, keenness of eyesight, and of hearing. In a subsequent short paper I propose briefly to discuss certain general principles that appear to me to underlie the construction of consistent scales of marks. It is sufficient now to say that I have not the least doubt as to the feasibility of constructing off-hand a valuable system of examination for immediate use, though it would be open to great improvement through experience. I would refer to the statement already quoted from the Report of the Civil Service Commissioners, in which they themselves, being experts in the general art of examination, also foresee no difficulty. The higher education of the country is now so pervaded by the spirit of athleticism, that it is not to be feared for a moment that any system of examination for bodily efficiency would become pedantic or fanciful. Many of the examiners in the present literary subjects are themselves past athletes. If the principle of considering physical merit in competitive examinations for Government appointments be once conceded, I am sure that we may safely trust the authorities to frame appropriate tests and methods. It is but reasonable to assume that they would proceed very cautiously at first, and gradually extend the system to its legitimate limit, whatever that may be, with increasing thoroughness.

My motive for bringing this topic before the British Association is the hope of obtaining a public recognition of its importance. Judging from the results of numerous private inquiries, I entertain no doubt that if the reasonableness and feasibility of the proposed reform were widely understood, a loud demand would arise from many sides, without arousing any opposition worth regarding, for the introduction of so salutary a measure. It would certainly be grateful to many parents who now lament the exclusively bookish character of the examinations, and are wont to protest against a system that gives no better chance to their own vigorous children of entering professions where bodily vigour is of high importance, than if they had been physically only *just not unfit* to receive an appointment.

On the Principle and Methods of assigning Marks for Bodily Efficiency. By FRANCIS GALTON, *F.R.S.*

THE principle and methods by which marks in examinations can justly be assigned is of no small interest to anthropologists, on account of their bearing on the art of describing the various degrees of human faculty among individuals and races. What will now be said is of general application, though it is written especially with reference to examinations in physical powers.

The question to be solved is of this kind. Suppose that one man can just distinguish a minute test object at the distance of 25 inches, another at that of 35, and again another at 45 inches, how should we mark them? We should be very rash if we marked them in the proportion of 25, 35, and 45, or even if, for some good reason, we had selected 25 as the lowest limit from which marks should begin to count, we should mark them as 0, 10, and 20.

Two separate considerations are concerned in the just determination of a scale of marks, namely, absolute performance and relative rank, which are apt to be confused in unknown and varying proportions.

Absolute performance is such as is expressed by the 25, 35, and 45 inches just spoken of. It is perfectly correct in some cases to mark, or let us say to pay, for this and this alone, upon the principle of piece-work, namely, that the pay ought to be proportionate to the work accomplished, or to the expected output in after life.

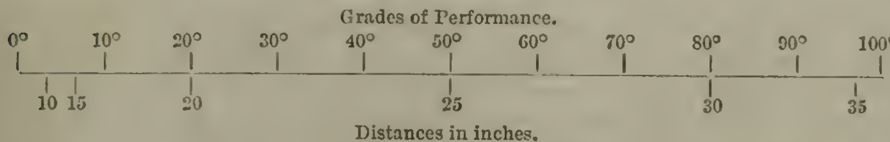
Relative rank is, however, on the whole, a more important consideration than the absolute amount of performance by which that rank is obtained. It has an importance of its own, because the conditions of life are those of continual competition, in which the man who is relatively strong will always achieve success, while the relatively weak will fail. The absolute difference between their powers matters little. The strongest even by a trifle will win the prize as completely as if he had been strongest by a large excess. Undertakings where many have failed are accomplished at last by one who usually is very little superior to his predecessors, but it is to just that small increment of absolute superiority that his success is due. Therefore it is clear that relative rank has at least as strong a claim for recognition as absolute performance, if not a much stronger one. They have each to be taken into separate consideration, and each to be separately marked. The precise meaning intended to be conveyed by the phrase 'relative rank' will be better understood further on.

Recurring to the example of keenness of eyesight, let the test object be words printed in diamond type, and the persons tested be Englishmen of the middle-classes, between the ages of 23–26, then the performance of reading diamond type at 25 inches happens to be strictly mediocre. Fifty per cent. of the many persons who were tested performed better than this, and fifty per cent. performed worse. The 35-inch performance was exceeded by only $2\frac{1}{2}$ per cent. of the persons tested, and as to the 45-inch performance it has not in my experience been reached at all. I have had 12,000 persons altogether tested in this way, of both sexes and of various ages, but not one of them has succeeded in reading diamond type at the distance of 45 inches. It is very rare to find one who can do so at 40 inches. Wherever superiority in eyesight is eminently desirable, it would

be absurd to make the marks for the three supposed cases to run proportionately either to 25, 35, and 45, or to 0, 10, and 20. The achievement of 45 inches would deserve much higher recognition. Relative rank and absolute performance should not be confused together.

I use the term relative rank in a large sense, with reference to all persons who have been, or are likely to become, candidates, and not to the small number of them who may happen to be present at a particular examination. Statistical tables concerning the class of persons in question have to be compiled from past examinations, and the rank of the individual has to be determined amidst these. I have often described how this is to be done ('Natural Inheritance,' p. 38: Macmillan & Co., 1889), but the form of a diagram that I now submit is a new and, I think, the simplest of all for the use of an examiner. It tells at a glance the rank held by a man among his fellows in respect to any single and separate faculty. The class from which it is constructed might have been of any length, subject to the condition that the distance between the limits *within which* it extends shall be always divided into centesimal grades; that is to say, running from 0° to 100°. This diagram refers to keenness of eyesight, but the method is of general application. I lay on the table several similar diagrams for various qualities, such as are hung up in my Anthropometric Laboratory in London.

Keenness of Eyesight, measured by the greatest distance in inches at which Diamond Type can be read.



This same method admits of being extended in more than one way. That for which there is most call is where the rank of the quality immediately in question has to be considered in reference to some other quality. Thus it is of little use to know the breathing capacity of the man unless we also know his stature or his weight. Lungs capacious enough to enable a small man to labour violently without panting would be wholly insufficient for the ordinary purposes of a giant, just as an excellent little boiler for a small steam-engine would be ineffective with a large one. The diagram appropriate to the case we are considering could not be compressed into a single line, but requires many. Successive lines in the same page would refer to the successive weights of, say, 100 lbs., 120 lbs., 140 lbs., and so on, and a diagram of breathing capacities for each of these weights would be constructed, but in pencil, just on the principle of that, shown above, for keenness of eyesight. The grades along the top of the page would refer equally to all the lines below. Then bold lines have to be drawn from above downward to connect all the pencilled entries of the same value, just as iso-bars, iso-therms, and other contour lines are drawn (to which the general name of *isograms* might well be given). This completes the figure of which I submit a specimen to the meeting. It hardly needs further description, either how to make or to use it.

When the quality that has to be marked depends upon more than one other quality, as breathing capacity may have to be marked with reference

both to weight and to stature, the simplest plan is to make a separate diagram for each inch or second inch of stature, which is quite near enough. I have, however, contrived to make a single page serve for the whole process by using a sliding strip of paper. I submit it for inspection, but do not care to describe it.

A strong reason for giving prominence to relative rank is that it affords the only feasible measure for many qualities, so that differences in absolute performance have to be inferred from it, according to a principle now familiar to most anthropologists, by using the well-known table of the Probability Integral. A small table based on the latter, but of a totally different form, that I have lately more than once published (*Op. cit.*, p. 205), is very convenient for this sort of work. The following is a brief extract from it:—

Grades of Rank from 0° *to* 100°, *together with the Deviations*[1] *from the Mean Values at those Grades.*

Grades . . .	0°	10°	20°	30°	40°	50°	60°	70°	80°	90°
Deviations . .	− infinity	−1·9	−1·3	−0·8	−0·4	0·0	+0·4	+0·8	+1·3	+1·9
Grades . . .	91°	92°	93°	94°	95°	96°	97°	98°	99°	100°
Deviations . .	+2·0	+2·1	+2·2	+2·3	+2·4	+2·6	+2·8	+3·1	+3·5	+ infinity

[1] The unit by which the deviations are measured is half the difference between the performances of the persons who respectively occupy the grades 25° and 75°.

Some of the consequences of marking separately the relative rank and the absolute performance are seen by the table below. Here the relative rank is in each case supposed to count between the grades of 50° and 100°. Then, if it alone is considered; a man who stands at the grade of 99° in a class that ranges within the limits of 0° and 100°, will be seen to get very nearly the full amount of 10 marks, whereas if absolute performance is alone considered, he would get no more than 7 marks, the full number of 10 being never actually reached, but only closely approached at some such high grade as 99·99 . . .° The figures in the table would have run very differently if the marks for relative rank had begun after 90° and not after 50°. Still more so, if the lower limit had been 99°, and more still if it had been 99·9°. It seems to me most reasonable, on the whole, that they should usually begin after 50°, as in the following table:—

Proportion of marks assigned to		Rank, 0° to 100°				
Relative	Absolute	55°	75°	95°	99°	99·99 . . .°
All	None	1·0	5·0	9·0	9·8	10·0
$\frac{1}{2}$	$\frac{1}{2}$	0·7	3·5	6·9	8·4	10·0
$\frac{1}{3}$	$\frac{2}{3}$	0·6	3·0	6·2	8·0	10·0
$\frac{1}{4}$	$\frac{3}{4}$	0·5	2·7	5·8	7·7	10·0
None	All	0·4	2·0	4·8	7·0	10·0

The general conclusion to which these remarks lead is, that before arranging scales of marks, the first step is to measure a large number of persons who are of the same class as the expected candidates; this has

already been done to a considerable extent at Cambridge, at Marlborough College and elsewhere. Thence to make tables, and to deduce diagrams from them like that referring to keenness of eyesight, in some cases, and like that referring to breathing capacity in relation to weight, in others. These will exactly determine the qualities of the men to be dealt with, in a statistical sense. It is now the part of those who have to fix the scales of marks to determine the grade at which rank shall begin to count, and to arrange the weight to be given respectively to relative rank and to absolute performance in each sort of examination. This and a few other obvious preliminaries having been settled, the construction of consistent scales of marks would follow almost as a matter of course.

Experiments at Eton College on the Degree of Concordance between different Examiners in assigning marks for Physical Qualifications. By A. A. SOMERVILLE.

AN experiment was made at Eton in July last, with the object of obtaining information upon the following points: (1) whether it is possible to frame a system of marking for physical excellence, based partly upon Mr. Galton's system and partly upon medical examination; (2) whether marks assigned by medical examiners would be as safe a test of excellence as those assigned, *e.g.* by examiners in English essay. The experiment was conducted as follows. A list of points was drawn up with the help of two able medical men. These points were: (1) breathing capacity, as tested by the spirometer; (2) hearing; (3) eyesight, tested by Snellen's type; (4) strength, tested by the grip dynamometer; (5) endurance, tested as follows,—after the maximum reading of the dynamometer had been obtained and registered for strength, it was again (as nearly as possible) obtained, and the number of seconds during which the candidate could hold the needle of the dynamometer between this reading and the reading 10 below it was taken by a stop-watch; (6) relation of height to weight; (7) girth and shape of chest; (8) general muscular development; (9) health record, particular inquiries being made as to rheumatism, asthma, and scarlatina; (10) general aspect and condition.

The first five points depend solely upon measurement, and consequently the marks of the two doctors are the same for those points. The next point was marked, partly by impression, and partly by reference to a table of averages, but it might be made to depend altogether upon averages. The seventh and eighth points were marked partly by measurement of chest, arms, and legs, and partly by examination. The last two points depend altogether upon medical opinion, and involved a thorough medical examination. Ten marks were assigned for each point, and the examination was conducted independently by the two doctors in separate rooms. Thirty-two boys were examined: (1) 20 Army Class boys, including 10 successful candidates at the recent Sandhurst and Woolwich Further Examinations, 2 members of the Cricket XI., and 2 members of the Rowing Eight; (2) 6 other members of the XI.; (3) the remaining 6 members of the Eight. The following table gives the final results, average differences per cent. being calculated with reference to a maximum 50, as the marks for the first five points are the same for the two examiners. (N.B.—Letters are substituted for the names of the boys.)

Army Boys						Six Members of the XI.			Six Members of the Eight		
A	$58\frac{1}{2}$	58	K	53	$56\frac{1}{2}$	A	60	59	A	$78\frac{1}{4}$	$79\frac{3}{4}$
B	74	$75\frac{1}{4}$	L	$71\frac{1}{2}$	77	B	59	61	B	73	$71\frac{1}{2}$
C	$81\frac{1}{2}$	83	M	57	62	C	$68\frac{1}{4}$	$71\frac{3}{4}$	C	$76\frac{3}{4}$	$78\frac{3}{4}$
D	68	$69\frac{1}{2}$	N	$59\frac{1}{2}$	65	D	$77\frac{3}{4}$	$71\frac{3}{4}$	D	$76\frac{1}{2}$	$73\frac{1}{2}$
E	$72\frac{1}{2}$	$70\frac{1}{2}$	O	64	$70\frac{1}{2}$	E	58	$65\frac{1}{4}$	E	67	$70\frac{1}{4}$
F	$44\frac{3}{4}$	$46\frac{1}{4}$	P	$51\frac{1}{2}$	58	F	$64\frac{3}{4}$	$73\frac{1}{2}$	F	$71\frac{1}{4}$	$76\frac{1}{2}$
G	$65\frac{1}{4}$	$68\frac{1}{4}$	Q	57	$65\frac{1}{4}$						
H	$66\frac{1}{2}$	$63\frac{1}{2}$	R	$60\frac{1}{2}$	$70\frac{1}{2}$						
I	$69\frac{1}{4}$	$72\frac{3}{4}$	S	$53\frac{1}{4}$	$62\frac{1}{4}$						
J	72	$76\frac{1}{2}$	T	57	$70\frac{1}{2}$						
Greatest difference . . $=13\frac{1}{2}$						Greatest difference . $=8\frac{3}{4}$			Greatest difference . $=5\frac{1}{4}$		
Least difference . . $=\frac{1}{2}$						Least difference . . . $=1$			Least difference . . $=1\frac{1}{2}$		
Per cent. Average difference . . $=9{\cdot}5$						Per cent. Average difference . $=9{\cdot}5$			Per cent. Average difference . $=5{\cdot}5$		

Average difference for 32 boys . . . . $=4{\cdot}375$ for max. 50.
$=8{\cdot}75$ per cent.

Nineteen of the twenty Army boys were subsequently examined in English essay, the essays being marked independently by two examiners, with the following results:

A	55	50	H	15	10	N	50	25
B	45	50	I	40	60	O	70	35
C	40	35	J	65	40	P	30	65
D	20	25	K	25	15	Q	45	20
E	15	12	L	35	20	R	60	25
F	55	40	M	15	30	S	40	15
G	35	25						

Greatest difference . . . . $=35$
Least difference . . . . $=3$
Per cent.
Average difference . . . . $=16{\cdot}7$

Comparing the average difference, 16·7 per cent., between the marks of the examiners in English essay, with the average difference, 9·5 per cent., for the same boys, between the marks of the medical examiners, it seems fair to conclude that the marks assigned by the latter are at least as trustworthy as those given for English essay, which may be taken as a sample subject in a literary examination.

It is hoped that similar experiments will be undertaken at other places, so that materials may be obtained for the comparison and discussion of different systems of marking, and for the construction, ultimately, of the best systems. Such experiments would be rendered all the more valuable by the introduction of fresh points of examination, and by variations in the method of assigning the marks for the different points.

TRANSACTIONS OF THE SECTIONS.

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Section A.—MATHEMATICAL AND PHYSICAL SCIENCE.

President of the Section—Captain W. de W. Abney, C.B., R.E., F.R.S., F.R.A.S.

THURSDAY, SEPTEMBER 12.

The President delivered the following Address:—

The occupant of this chair has a difficult task to perform, should he attempt to address himself to all the various subjects with which this Section is supposed to deal. I find that it has very often been the custom that some one branch of science should be touched upon by the President, and I shall, as far as in me lies, follow this procedure.

This year is the jubilee of the practical introduction of photography by Daguerre and Fox Talbot, and I have thought I might venture to take up your time with a few remarks on the effect of light on matter. I am not going into the history of photography, nor to record the rivalries that have existed in regard to the various discoveries that have been made in it. A brand-new history of photography, I dare say, would be interesting, but I am not the person to write one; and I would refer those who desire information as to facts and dates to histories which already exist. In foreign histories perhaps we English suffer from speaking and writing in a language which is not understanded of the foreign people; and the credit of several discoveries is sometimes allotted to nationalities who have no claim to them. Be that as it may, I do not propose to correct these errors or to make any reclamations. I leave that to those whose leisure is greater than mine.

I have often asserted, and I again assert, that there should be no stimulus for the study of science to be compared to photography. Step by step, as it is pursued, there should be formed a desire for a knowledge of all physical science. Physics, chemistry, optics, and mathematics are all required to enable it to be studied as it should be studied; and it has the great advantage that experimental work is the very foundation of it, and results of some kind are always visible. I perhaps am taking an optimist view of the matter, seeing there are at least 25,000 living facts against my theory, and perhaps not 1 per cent. of them in its favour. I mean that there are at least 25,000 persons who take photographs, and scarcely 1 per cent. who know or care anything of the 'why or wherefore' of the processes, so far as theory is concerned. If we call photography an applied science, it certainly has a larger number who practise it, and probably fewer theorists, than any other.

He would be a very hardy man who would claim for Nièpce, Daguerre, or Fox Talbot the discovery of photographic action on matter. The knowledge that such an action existed is probably as old as the fair-skinned races of mankind, who must have recognised the fact that light, and particularly sunlight, had a tanning action on the epidermis, and the women then, as now, no doubt took their precautions against it. As to what change the body acted upon by light underwent it need scarcely be said that nothing was known, and perhaps the first scientific experi-

ment in this direction was made rather more than a hundred years ago by Scheele, the Swedish chemist, who found that when chloride of silver was exposed to light chlorine was given off. It was not till well in the forties that any special attention was given to the action that light had on a variety of different bodies; and then Sir John Herschel, Robert Hunt, Becquerel, Draper, and some few others carried out experiments which may be termed classical. Looking at the papers which Herschel published in the 'Philosophical Transactions' and elsewhere, it is not too much to say that they teem with facts which support the grand principle that without the absorption of radiation no chemical action can take place on a body; in other words, we have in them experimental proofs of the law of the conservation of energy. Hunt's work, 'Researches on Light,' is still a textbook to which scientific photographers refer, and one is sometimes amazed at the amount of experimental data which is placed at our disposal. The conclusions that Hunt drew from his experiments, however, must be taken with caution in the light of our present knowledge, for they are often vitiated by the idea which he firmly held, that radiant heat, light, and chemical action, or actinism, were each of them properties, instead of the effects, of radiation. Again, we have to be careful in taking seriously the experiments carried out with light of various colours when such colours were produced by absorbing media. It must be remembered that an appeal to a moderately pure spectrum is the only appeal which can be legitimately made as to the action of the various components of radiation, and even then the results must be carefully weighed before any definite conclusion can be drawn. No photographic result can be considered as final unless the experiments be varied under all the conditions which may possibly arise. Coloured media are dangerous for enabling trustworthy conclusions to be drawn, unless the character of such media have been thoroughly well tested and the light they transmit has been measured. An impure spectrum is even more dangerous to rely upon, since the access of white light would be sure to vitiate the results.

Perhaps one of the most puzzling phenomena to be met with in photography is the fact that the range of photographic action is spread over so large a portion of the spectrum. The same difficulty of course is felt in the matter of absorption, since the one is dependent on the other. Absorption by a body we are accustomed, and indeed obliged by the law of the conservation of energy, to consider as due to the transference of the energy of the ether wave-motion to the molecules and atoms comprising the body by increasing the vibrations of one or both.

In the case where chemical action takes place we can scarcely doubt that it is the atoms which in a great measure take up the energy of the radiation falling on them, as chemical action is dependent on the liberation of one or more atoms from the molecule, whilst, when the swings of the molecules are increased in amplitude we have a rise in temperature of the body. I shall confine the few remarks I shall make on this subject to the case of chemical action. The molecule of a silver salt, such as bromide of silver, chemists are wont to look upon as composed of a limited and equal number of atoms to form the molecule. When we place a thin slab of this material before the slit of the spectroscope we find a total absorption in the violet and ultra-violet of the spectrum, and a partial absorption in the blue and green, and a diminishing absorption in the yellow and red. A photographic plate containing this same salt is acted upon in exactly the same localities and in the same relative degree as where the absorption takes place. Here, then, we have an example of, it may be, the vibrations of four atoms, one of which at least is isochronous or partially so, with the waves composing a large part of the visible spectrum. The explanation of this is somewhat obscure. A mental picture, however, may help us. If we consider that, owing to the body acted upon being a solid, the oscillations of the molecules and atoms are confined to a limited space, it probably happens that between the times in which the atoms occupy, in regard to one another, the same relative positions, the component vibrations of, say, two of the atoms vary considerably in period. An example of what I mean is found in a pendulum formed of a bob and an elastic rod. If the bob be made to vibrate in the usual manner, and at the same time the elastic rod be elongated, it is manifest that we have a pendulum of ever-varying length. At each instant of time the period

of vibration would differ from that at the next instant, if the oscillations were completed. It is manifest that increased amplitude would be given to the pendulum swings by a series of well-timed blows differing very largely in period; at the same time there would be positions of the pendulum in which some one series of well-timed blows would produce the greatest effect. In a somewhat similar manner we should imagine that the ethereal waves should produce increased amplitude in the swing of the atoms between very wide limits of period, and, further, that there should be one or more positions in the spectrum when a maximum effect is produced.[1] I would here remark that the shape of the curves of sensitiveness, when plotted graphically, of the different salts of silver to the spectrum have a marked resemblance to the graphically drawn curves of the three colour sensations of the normal eye, as determined by Clerk Maxwell. May not the reason for the form of the one be equally applicable for the other? I only throw this out as evidence, not conclusive indeed, that the colour-sensitiveness of the eye is more probably due to a photographic action on the sensitive retina than to a merely mechanical action. That this is the case I need scarcely say has several times been propounded before.

The ease with which a silver salt is decomposed is largely, if not quite, dependent on the presence of some body which will take up some of the atoms which are thrown off from it. For instance, in chloride of silver we have a beautiful example of the necessity of such a body. In the ordinary atmosphere the chloride is, of course, coloured by the action of light; but if it be carefully dried and purified, and placed in a good vacuum, it will remain uncoloured for years in the strongest sunlight. In this case the absence of air and moisture is sufficient to prevent it discolouring.

If in the vacuum, however, a drop of mercury be introduced the coloration by light is set up. We have the chlorine liberated from the silver and combining with the mercury vapour, and a minute film of calomel formed on the sides of the vessel.

Delicate experiments show that not only is this absorbent almost necessary when the action of light is so strong or so prolonged that its effect is visible, but also when the exposure or intensity is so small that the effect is invisible and only to be found by development. The necessity for this absorbent is not far to seek. If, for instance, silver chloride be exposed to light in vacuo, although the chlorine atoms may be swung off from the original molecule, yet they may only be swung off to a neighbouring molecule which has lost one of its chlorine atoms, and an interchange of atoms merely takes place. If, however, a chlorine absorbent be present which has a greater affinity for chlorine than has the silver chloride which has lost one of its atoms, then we may consider that the chlorine atoms will be on the average more absorbed by the absorbent than by the subchloride molecules. The distribution of the swung-off atoms between the absorbent and the subchloride will doubtless be directly proportional to their respective affinities for chlorine, and so for the other salts of silver. If this be so, then it will be seen that the greater the affinity of the absorbent for the halogen the more rapid will be the decomposition of the silver salt. This, then, points to the fact that if any increase in the sensitiveness of a silver salt is desired it will probably be brought about by mixing with it some stronger halogen absorbent than has yet been done.

The question as to what is the exact product of the decomposition of a silver salt by the action of light is one which has not as yet been fully answered. For my own part, I have my strong beliefs and my disbeliefs. I fully believe the first action of light to be a very simple one, though this simple action is masked by other actions taking place, due to the surroundings in which it takes place. The elimination of one atom from a molecule of a silver salt leaves the molecule in an unsatisfied condition, and capable of taking up some fresh atom. It is this capacity which seemingly shrouds the first action of light, since when exposure is prolonged the molecules take up atoms of oxygen from the air or from the moisture in it. Carey Lea, of Philadelphia, has within the last three years given some interesting experiments on the composition of what he calls the

[1] The effect of perfect and nearly perfect synchronism of one oscillation upon another is also to be found exemplified in my *Treatise on Photography*. Text Book of Science Series.

photochloride of silver, which is the chloride coloured by light, and Professor Hodgkinson has also taken up the matter. The conclusions the former has drawn are, to my mind, scarcely yet to be accepted. According to the latter experimentalist the action of light on silver chloride is to form an oxidised sub-salt. This can hardly be the case, except under certain conditions, since a coloured compound is obtained when the silver chloride is exposed in a liquid in which there is no oxygen present.

This coloration by light of the chloride of silver naturally leads our thoughts to the subject of photography in natural colours. The question is often asked when photography in natural colours will be discovered. Photography in natural colours not only has been discovered, but pictures in natural colours have been produced. I am not alluding to the pictures produced by manual work, and which have from time to time been foisted on a credulous public as being produced by the action of light itself, much to the damage of photography and usually to the so-called inventors. Roughly speaking, the method of producing the spectrum in its natural colours is to chlorinise a silver plate, expose it to white light till it assumes a violet colour, heat till it becomes rather ruddy, and expose it to a bright spectrum. The spectrum colours are then impressed in their natural tints. Experiment has shown that these colours are due to an oxidised product being formed at the red end of the spectrum and a reduced product at the violet end. Photography in natural colours, however, is only interesting from a scientific point of view, and, so far as I can see, can never have a commercial value. A process to be useful must be one by which reproductions are quickly made; in other words, it must be a developing and not a printing process, and it must be taken in the camera, for any printing process requires not only a bright light but also a prolonged exposure. Now it can be conceived that in a substance which absorbs all the visible spectrum the molecules can be so shaken and sifted by the different rays that eventually they sort themselves into masses which reflect the particular rays by which they are shaken; but it is almost—I might say, quite—impossible to believe that when this sifting has only been commenced, as it would be in the short exposure to which a camera picture is submitted, the substance deposited to build up the image by purely chemical means would be so obliging as to deposit in that the particular size of particle which should give to the image the colour of the nucleus on which it was depositing. I am aware that in the early days of photography we heard a good deal about curious results that had been obtained in negatives, where red brick houses were shown as red and the blue sky as bluish. The cause of these few coincidences is not hard to explain, and would be exactly the same as when the red brick houses were shown as bluish and the sky as red in a negative. The records of the production of the latter negatives are naturally not abundant, since they would not attract much attention. I may repeat, then, that photography in natural colours by a printing-out process—by which I mean by the action of light alone—is not only possible but has been done, but that the production of a negative in natural colours from which prints in natural colours might be produced appears, in the present state of our knowledge, to be impossible. Supposing it were not impracticable, it would be unsatisfactory, as the light with which the picture was impressed would be very different from that in which it would be viewed. Artists are fully aware of this difficulty in painting, and take their precautions against it.

The nearest approach to success in producing coloured pictures by light alone is the method of taking three negatives of the same subject through different-coloured glasses, complementary to the three colour sensations which together give to the eye the sensations of white light. The method is open to objection on account of the impure colour of the glasses used. If a device could be adopted whereby only those three parts of the spectrum could be severally used which form the colour sensations, the method would be more perfect than it is at present. Even then perfection could not be attained, owing to a defect which is inherent in photography, and which cannot be eliminated. This defect is the imperfect representation of gradation of tone. For instance, if we have a strip graduated from what we call black to white (it must be recollected that no tone can scientifically be called black, and none white), and photograph it, we shall find that in

a print from the negative the darkness which is supposed to represent a grey of equal mixtures of black and white by no means does so unless the black is not as black nor the white as white as the original. The cause of this untruthfulness in photography has occupied my attention for several years, and it has been my endeavour to find out some law which will give us the density of a silver deposit on a negative corresponding with the intensity of the light acting. I am glad to say that at the beginning of this year a law disclosed itself, and I find that the transparency of a silver deposit caused by development can be put into the form of the law of error.

This law can be scarcely empiric, though at first sight it appears that the manipulations in photography are so loose that it should be so. It is this very looseness, however, which shows that the law is applicable, since in all cases I have tried it is obeyed. That there are theoretical difficulties cannot be denied, but it is believed that strictly theoretical reasoning will eventually reconcile theory with observation.

This want of truth in photography in rendering gradation, then, puts it out of the range of possibility that photography in natural colours can ever be exact, or that the three negatives system can ever get over the difficulty.

One of the reproaches that in early days was cast at photography was its inability to render colour in its proper monochromatic luminosity. Thus whilst a dark blue was rendered as white in a print—that is, gave a dense deposit in a negative—bright yellow was rendered as black in a print or nearly so—that is, as transparent or nearly transparent glass in the negative. To the eye the yellow might be far more luminous than the blue, but the luminosity was in the photograph reversed. I need scarcely say that the reason of this want of truth in the photograph is due to the want of sensitiveness of the ordinarily used silver salts to the least refrangible end of the spectrum. Some fifteen years ago Dr. H. W. Vogel announced the fact that when silver salts were stained with certain dyes they became sensitive to the colour of the spectrum, which the dyes absorbed. This at once opened up possibilities, which, however, were not at once realised, owing perhaps to the length of exposure required when the collodion process was employed. Shortly after the gelatine process was perfected, the same dyes were applied to plates prepared by this method, which, although they contained the same silver salts as the old collodion process, yet *per se* were very much more sensitive. A new era then dawned for what has been termed isochromatic and orthochromatic photography. The dyes principally used are those belonging to the eosin group and cyanin—not the ordinary cyanine dye of commerce, but that discovered by Greville Williams. For a dye to be of use in this manner it may be taken as an axiom—first propounded by the speaker, it is believed—that it must be fugitive, or that it must be capable of forming a silver compound. The more stable a dye is the less effective it is. If we take as an example cyanine we find that it absorbs in the orange and slightly in the red. If paper or collodion stained with this colouring-matter be exposed to the action of the spectrum, it will be found that the dye bleaches in exactly the same part of the spectrum as that in which it absorbs, following, indeed, the universal law I have already alluded to. If a film containing a silver salt be dyed with the same, it will be found that, whilst the spectrum acts on it in the usual manner—viz. darkening it in the blue, violet, and ultra-violet—the colour is discharged where the dye absorbs, showing that in one part of the spectrum it is the silver salt which is sensitive, and that in the other it is the colouring-matter. If such a plate, after exposure to the spectrum, be developed it will be found that at both parts a deposit of silver takes place; and further, when the experiment is carefully conducted, if a plate with merely cyanine-coloured collodion be exposed to the spectrum and bleached in the orange, and after removal to the dark room another film containing a silver salt be applied and then a developer, a deposit of silver will take place where the bleaching has occurred. This points to the fact that the molecules of a fugitive dye, when altered by light, are unsatisfied, and are ready to take up an atom or atoms of silver, and other molecules of silver will deposit on such nuclei by an action which has various names in physical science, but which I

don't care to mention. This is the theory which I have always advocated, viz. that the dye by its reduction acts as a nucleus on which a deposit of silver can take place. It met with opposition; a rival theory which makes the dye an 'optical sensitiser'—an expression which is capable of a meaning which I conceive contrary to physical laws—being run against it. The objection to what I may call the nucleus theory is less vigorous than it has been, and its diminution is due perhaps to the more perfect understanding of the meaning of each other by those engaged in the controversy. To my mind, the action of light on fugitive dyes is one of the most interesting in the whole realm of photography, as eventually it must teach us something as to the structure of molecules, and add to the methods by which their coarseness may be ascertained. Be the theory what it may, however, a definite result has been attained, and it is now possible to obtain a *fair* representation of the luminosity of colours by means of dyed films. At present the employment of coloured screens in front of the lens, or on the lens itself, is almost an essential in the method when daylight is employed, but not till some dye is discovered which shall make a film equally sensitive for the same luminosity to the whole visible spectrum will it be possible to make orthochromatic photography as perfect as it can be made. The very fact that no photograph of even a black and white gradation will render the latter correctly must of necessity render any process imperfect, and hence in the above sentence I have used the expression 'as perfect as it can be made.'

The delineation of the spectrum is one of the chief scientific applications to which photography has been put. From very early days the violet and ultra-violet end of the spectrum have been favourite objects for the photographic plate. To secure the yellow and red of the spectrum was, however, till of late years, a matter of apparently insurmountable difficulty; whilst a knowledge of that part of the spectrum which lies below the red was only to be gained by its heating effect. The introduction of the gelatine process enabled the green portion of the spectrum to impress itself on the sensitive surface; whilst the addition of various dyes, as before mentioned, allowed the yellow, the orange, and a portion of the red rays to become photographic rays. Some eight years ago it was my own good fortune to make the dark infra-red rays impress themselves on a plate. This last has been too much a specialty of my own, although full explanations have been given of the methods employed. By preparing a bromide of silver salt in a peculiar manner one is able so to modify the molecular arrangement of the atoms that they answer to the swings of those waves which give rise to these radiations. By employing this salt of silver in a film of collodion or gelatine the invisible part of the spectrum can be photographed and the images of bodies which are heated to less than red heat may be caused to impress themselves upon the sensitive plate. The greatest wave-length of the spectrum to which this salt is sensitive so far is 22,000 λ, or five times the length of the visible spectrum. The exposure for such a wave-length is very prolonged, but down to a wave-length of 12,000 it is comparatively short, though not so short as that required for the blue rays to impress themselves on a collodion plate. The colour of the sensitive salt is a green blue by transmitted light; it has yet to be determined whether this colour is all due to the coarseness of the particles or to the absorption by the molecules. The fact that a film can be prepared which by transmitted light is yellow, and which may be indicative of colour due to fine particles, together with an absorption of the red and orange, points to the green colour being probably due to absorption by the molecules. We have thus in photography a means of recording phenomena in the spectrum from the ultra-violet to a very large wave-length in the infra-red—a power which physicists may some day turn to account. It would, for instance, be a research worth pursuing to photograph the heavens on a plate prepared with such a salt, and search for stars which are nearly dead or newly born, for in both cases the temperature at which they are may be such as to render them below red heat, and therefore invisible to the eye in the telescope. It would be a supplementary work to that being carried out by the brothers Henri, Common, Roberts, Gill, and others, who are busy securing photographic charts of the heavens in a manner which is beyond praise.

There is one other recent advance which has been made in scientific photography to which I may be permitted to allude, viz. that from being merely a qualitative recorder of the action of light it can now be used for quantitative measurement. I am not now alluding to photographic actinometers, such as have been brought to such a state of perfection by Roscoe—but what I allude to is the measurement and interpretation of the density of deposit in a negative. By making exposures of different lengths to a standard light, or to different known intensities of light on the same plate on which a negative has to be taken, the photographic values of the light acting to produce the densities on the different parts of the developed image can be readily found. Indeed, by making only two different exposures to the same light, or two exposures to two different intensities of light, and applying the law of density of deposit in regard to them, a curve is readily made from which the intensities of light necessary to give the different densities of deposit in the image impressed on the same plate can be read off. The application of such scales of density to astronomical photographs, for example, cannot but be of the highest interest, and will render the records so made many times more valuable than they have hitherto been. I am informed that the United States astronomers have already adopted the use of such scales, which for the last three years I have advocated, and it may be expected that we shall have results from such scaled photographs which will give us information which would before have been scarcely hoped for.

One word as to a problem which we may say is as yet only qualitatively and not quantitatively solved. I refer to the interchangeability of length of exposure for intensity of light. Put it in this way. Suppose, with a strong light, L, a short exposure, E, be given, a chemical change, C, is obtained: will the same change C be obtained if the time is only an nth of the light L, but n times the exposure? Now this is a very important point, more particularly when the body acted upon is fairly stable, as, for instance, some of the water-colour pigments, which are known to fade in sunshine, but might not be supposed to do so in the light of an ordinary room, even with prolonged exposure. Many experiments have been made at South Kensington as regards this, more especially with the salts of silver, and it is found that for any ordinary light, intensity and exposure are interchangeable, but that when the intensity of light is very feeble, say the $\frac{1}{1000000}$ of ordinary daylight, the exposure has to be rather more prolonged than it should be, supposing the exact interchangeability always held good; but it has never been found that a light was so feeble that no action could take place. Of course it must be borne in mind that the stability of the substance acted upon may have some effect; but the same results were obtained with matter which is vastly more stable than the ordinary silver salts. It may be said in truth that almost all matter which is not elemental is, in time and to some degree, acted upon by light.

I should like to have said something regarding the action of light on the iron and chromium salts, and so introduced the subject of platinotype and carbon printing, the former of which is creating a revolution in the production of artistic prints. I have, however, refrained from so doing, as I felt that the President of Section A should not be mistaken as the President of Section B. Photogravure and the kindred processes were also inviting subjects on which to dwell, more especially as at least one of them is based on the use of the same material as that on which the first camera picture was taken by Niépce. Again, a dread of trenching on the domains of art restrains me.

Indeed, it would have been almost impossible, and certainly impolitic, in the time which an address should occupy, to have entered into the many branches of science and art which photography covers. I have tried to confine myself to some few advances that have been made in its theory and practice.

The discovery of the action of light on silver salts is one of the marvels of this century, and it is difficult to overrate the bearing it has had on the progress of science, more especially physical science. The discovery of telegraphy took place in the present reign, and two years later photography was practically introduced; and no two discoveries have had a more marked influence on mankind. Telegraphy, however, has had an advantage over photography in the scientific progress that it has made, in that electrical currents are subject to exact measurement, and that

empiricism has no place with it. Photography, on the other hand, has laboured under the disadvantage that, though it is subject to measurement, the factors of exactitude have been hitherto absent. In photography we have to deal with molecules the equilibrium of whose components is more or less indifferent according to the process used; again, the light employed is such a varying factor that it is difficult to compare results. Perhaps more than any other disadvantage it labours under is that due to quackery of the worst description at the hands of some of its followers, who not only are self-asserting, but often ignorant of the very first principles of scientific investigation. Photography deserves to have followers of the highest scientific calibre; and if only some few more real physicists and chemists could be induced to unbend their minds and study the theory of an applied science which they often use for record or for pleasure, we might hope for some greater advance than has hitherto been possible.

Photography has been called the handmaid of Art; I venture to think it is even more so the handmaid of Science, and each step taken in perfecting it will render it more worthy of such a title.

The following Reports and Papers were read:—

1. *Fifth Report of the Committee for Promoting Tidal Observations in Canada.*—See Reports, p. 27.

2. *Report of the Committee for preparing Instructions for the Practical Work of Tidal Observation.*

3. *Fifth Report of the Committee for the Harmonic Analysis of Tidal Observation.*

4. *On the Heliocentric Longitudes of Cometic Perihelia.*[1] *By* HENRY MUIRHEAD, *M.D., LL.D.*

In 1880 I read a paper to the Philosophical Society of Glasgow (see vol. 13, pp. 34–46) on the relations of sunspot maxima and minima to the bearing of Jupiter to the sun's line of flight in space. In that paper I called attention to the longitudinal relations which the perihelia of comets seem to bear to our primary's line of travel, and pointed out that, taking the two groups of comets given by Mr. Hind in the 'Encyclopædia Britannica' (article 'Comet'), with 13 others which I was able to find in 'Nature,' up to date—in all 35—and arranging them circularly according to their heliocentric longitudes, they very largely crowded into the quadrants which the sun's line of flight bisects in his progress in the direction of helial longitude $263\frac{3}{4}°$. Attention was also called to certain relations of some phenomena of terrestrial magnetism and the three larger planets crossing the sun's line of flight.

Recently I have gone over the succeeding volumes of 'Nature,' noting all the cometic perihelia recorded therein (41 more). These, too, show a tendency to avoid the normals to the line; so much so, indeed, that, taking the central *flank octants,* the quadrant thus constituted shows only 9 cometic perihelia out of a total of 75.

Moreover, in Guillemin's 'World of Comets' (Glaisher's Translations, p. 186), we are furnished with a total of 257 cometic perihelia given below. In this table, in the 60° intervening between 150° and 210° forming the sinister flank division (*of the plate*) we have the numbers $14 + 16 = 30$, and between 330° and 30° the dexter flank division $8 + 17 = 25$. Well, neglecting the intermediate twelfths which show a remarkably intermediate character, viz., 24, 21, 21, 22, let us now

[1] Will appear *in extenso* in vol. xxi. of the *Proc. Glas. Phil. Soc.*

take those approximating to the line of flight. Those between 60° and 120° are $30 + 25 = 55$, and those between 240° and 300° $29 + 30 = 59$; for both 114, or more than double those of the flank divisions of equal extent. Had I been able to obtain much smaller segments than 60 degrees, the differences as contrasts would likely have been much more striking. I make no further comment than to ask, is it likely that our sun's primary lies to the dexter side? referring here to the *sides* of the plate.

TABLE.

Longitudes of perihelia comprised between	Number of perihelia of comets	Longitudes of perihelia comprised between	Number of perihelia of comets
0° and 30°	−17	180° and 210°	−16
30 " 60	24	210 " 240	21
60 " 90	+30	240 " 270	+29
90 " 120	+25	270 " 300	+30
120 " 150	21	300 " 330	22
150 " 180	−14	330 " 360	− 8

The divisions bisected by the line of flight are marked thus +, the flank number thus −; the intermediate are unmarked.

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5. *On Cometic Nebulæ. By* Professor A. W. RÜCKER, *M.A., F.R.S.*

Mr. Lockyer has suggested ('Proc. Roy. Soc.' No. 266, vol. xliv. p. 10, 1888) that comet-like nebulæ may be caused by the passage of a very dense swarm through a sheet of meteorites, the relative velocity of the two being considerable. The author has therefore attempted to calculate the increase in the number of collisions which take place in the rear of an attracting mass which passes through a swarm of meteorites so sparsely scattered through space that the main effects of the attraction are produced in a distance which is small compared with the length of the mean free path.

Assuming with Clausius that the particles have equal velocities equally distributed in all directions, which are small compared with the relative velocity of approach, the collisions will be most numerous within a cone the vertex of which is the attracting body or nucleus, and which contains the lines which are parallel to the relative velocities of the individual meteorites and the nucleus when at an infinite distance apart.

Let ω be the number of collisions per unit of time and volume at a point the length of the perpendicular from which on the central line of the cone is ξ, intersecting it at a distance z from the nucleus. Let the radius of the circle in which the cone cuts the plane through z perpendicular to its central line be R. Then if v be the velocity of agitation of the meteorites at infinity, and V the relative velocity of approach, $\mathrm{R} = z\dfrac{v}{\mathrm{V}}$. Let n be the number of meteorites per unit of volume at infinity, and μ the acceleration due to the nucleus at unit distance, and let δ be the diameter of a meteorite. Within the circle of radius R the quantity ω is constant, and

$$\omega = \sqrt{2}\pi^2\delta^2 n^2 \mu^{\frac{3}{2}} z^{\frac{1}{2}} / \mathrm{R}^2\mathrm{V}^2$$

without the circle but near to it;

$$\omega = \frac{2\sqrt{2}\pi\delta^2 n^2 \mu^{\frac{3}{2}} z^{\frac{1}{2}}}{\mathrm{R}^2\mathrm{V}^2}\left\{1 - \frac{\mathrm{R}}{\xi} - \sqrt{1 - \frac{\mathrm{R}^2}{\xi^2}} + \sin^{-1}\frac{\mathrm{R}}{\xi}\right\}.$$

If ξ is large relatively to z, and if $\xi = r\sin\theta$, $z = r\cos\theta$, and $u = 1/r$,

$$\omega = \frac{\pi\delta^2 n^2 \mu^2 u^2 \sqrt{2}}{\mathrm{V}^3(1 - \cos\theta)\sqrt{1 - \cos\theta + 4au}}$$

These formulæ are only applicable on the hypothesis that the chances of a second collision may be neglected, and the author illustrates them by a case in which

this condition is fulfilled. A globular nebula, the diameter of which is ten times the radius of the orbit of Neptune, and consisting of meteorites 1 cm. in diameter, and of the density of iron, is supposed to have a total mass equal to 0·001 of that of the sun. Its internal constitution is not such as could really exist, in that its density and velocity of agitation are supposed to be uniform. It would probably be possible to extend the method to cases in which these quantities vary. The velocity of agitation is assumed to be 0·1 km. per second, and the relative velocity of approach 4 km. per second. This description of the nebula will also apply approximately to a part of which the distance from the nucleus is ten times the radius of the orbit of Neptune, except that the velocity of approach will have increased. Provided, then, that comparatively few collisions occur while the nebula moves from this distance to the nucleus, no great error will be introduced if the calculations are conducted on the supposition that it has travelled from an infinite distance without internal collision. It is shown that these conditions are amply fulfilled in the case selected, and that at a distance from the nucleus of 10^7 km., and throughout a disk of which the radius is $\frac{1}{4} \times 10^6$ km., one collision per second would take place at points about 170 km., or, in round numbers, 100 miles apart. If we assume that the ordinary formulæ for gases may be applied to the original nebula, this shows an increase in collision frequency per unit volume in the ratio $10^{10}:1$. On the other hand, it is difficult to suppose that luminosity would be produced unless the collisions took place at points in closer proximity. The assumptions on which the method of calculation is based do not, however, permit of its application to nebulæ, of which the density is much more than ten times greater than that chosen in the example. All, therefore, that the calculation shows is that in the limiting cases of great rarity, and at the distance from the nucleus considered, we cannot expect a collision in every second at points much nearer than 100 miles apart. In the case of denser nebulæ different mathematical methods would have to be employed. The enormous increase in collision frequency is, however, well illustrated by the calculations. In the case considered it is of the order 10^{10}.

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6. *Re-examination of the Spectra of 23 Gas-Vacuum, End-on Tubes, after six to ten years of Existence and Use.*[1] *By* C. Piazzi Smyth.

This inquiry began in an attempt to ascertain by refined mensurations whether there was any sensible difference of spectral place for hydrogen lines, when they appeared adventitiously and scantily in tubes of other and very different gases, or in tubes of nothing but pure and abundant hydrogen by original intention?

But after having obtained a negative in every case, the inquirer became more taken up with the *changes* that had occurred in certain of the tubes subsequent to 1880, when he published upon them in the 'Trans. Roy. Soc. Edinburgh.'

Thus a chlorine tube, of which it was printed in 1880 that it was then still showing its chlorine lines, though fainter, after two years' use; while carbon bands and hydrogen lines had begun to appear; yet now, in 1889, it has nothing but hydrogen lines, and in great brilliance, to show.

Again, an iodine tube which had a comparatively large quantity of solid iodine granules introduced into, and sealed up in, its interior eleven years ago; and showed then a splendid spectrum of 148 measured iodine lines, extending discontinuously from red to violet, and had nothing else, *save* three very faint puny images of the three principal lines of hydrogen—this tube, in 1889, has not a single iodine line now left; but its spectrum, which is brighter than ever, is composed of nothing but hydrogen lines, so that the once solid iodine granules would seem to be partly changed into hydrogen, and partly deposited on the inside of the tube as yellow haze, besides leaving a trifle of loose dust.

The author also mentions with much satisfaction that a London maker, Mr. Charles Casella, transcended all others by supplying him with one tube of CO, two of N, and two of O, which have, through six years of existence and work, shown their respective spectra without a trace of hydrogen.

[1] Printed *in extenso* in the *Chemical News*, Nov. 8, 1889.

7. *On the Tones of Bells.* *By* Lord RAYLEIGH, *LL.D.*, *Sec.R.S.*

Observations have been made upon a considerable number of bells of the usual church pattern, including the five of the Terling belfry. The pitch of the various tones, usually five for each bell, was fixed by comparison with a harmonium, and with the aid of resonators. The results are given in the accompanying table; where + or − after a note indicates that the pitch of the bell was a little higher or lower respectively than the note of the harmonium. Where two notes are recorded, the pitch of the bell was about midway between.

Mears and Stainton, 1888	Taylor (Ampton), 1888	Belgian Bell, Mr. Hawcis	Terling 5, Osborn, 1783	Terling 4, Mears, 1810	Terling 3, Graye, 1623	Terling 2, Gardiner, 1723	Terling 1, Warner, 1863
e'	e'fl−	d'−	g−	a+	a sh+	d'−	d'+
c''	a'' −	c''sh−d''	g'−	g'sh−	a'+	a'sh−	b'+
f''+	f'' +	f''	a'+	b'+	c''sh+	d''+	e''
b''fl	b''fl−b''	a''−	d'−	d''sh−e''	e''+	g'sh+	g'sh+
d'''	d'''	—	f''sh−	g''sh−	a''sh	b''+	c'''sh+

The nominal pitch of the bells appears to depend upon the *highest* of the tones here recorded. When ringing in sequence, and heard from a distance, the bells of the Terling peal were judged to give $f\sharp$, $g\sharp$, $a\sharp$, b, $c\sharp$, no regard being had to the octave.

The various tones of any bell correspond, of course, to various modes of vibration. Thus in the case of the first bell upon the above list the gravest note, e', corresponds to a mode with 4 nodal meridians, viz. meridians along which the motion is purely tangential. This is the ordinary mode of vibration of a finger bowl or glass receiver. There is no nodal circle; but this tone is at its loudest when the bell is struck about half-way up. The agreement of pitch with the harmonium is sufficiently good for the bell to respond when e' is sounded upon the instrument.

The next note, c'', may also be easily excited by the harmonium or by the voice; and again, in this case there are 4 (and but 4) nodal meridians. But now there is in addition a nodal circle, situated about a quarter of the way up. If we tap along a meridian, the tone in question disappears when the circle is reached, and reappears when the circle is passed. The mode corresponding to f'' + has 6 nodal meridians, and no well-defined nodal circle of latitude. The sound becomes very faint when the place of tapping is much removed from the sound-bow.

The tone b'' flat is scarcely heard when the bell is struck on the sound-bow in the normal manner. It comes out best at about half-way up. In this case also there are 6 nodal meridians. The highest tone which could well be investigated, d''', appears to be the one which characterises the bell. It is heard best when the sound-bow is struck and but little over the whole of the upper three-quarters of the bell. In this mode there are 8 nodal meridians.

From a musical point of view it would seem that all the bells are far removed from perfection; while the differences of relative pitch in the various cases recorded in the table indicate that it may be possible to effect an improvement, even to the extent of bringing all the five tones into harmonious relations. But the fourth tone may probably be disregarded, as it is scarcely heard in the normal use of the bell. The quality of sound is, however, very difficult to estimate; and even the imperfect octaves, of which several examples occur, give much less of a dissonant effect than might have been expected.

It is scarcely necessary to say that each of the tones recorded is in reality *double*, and that from want of symmetry the components of each pair are usually separated to a sensible degree.

The sequence of modes and tones differs altogether from what the theory of thin shells would suggest, and this need not be a matter of surprise when we consider how very considerable is the thickness of the sound-bow in comparison with the distance between consecutive nodal meridians.

A so-called hemispherical bell of Mears and Stainton gives results altogether different from the above, and more in agreement with the theory of thin shells.

The tones were *e fl*, *f'sh*, *e''*, *b''*, corresponding respectively to 4, 6, 8, 10 nodal meridians. The sounds in all cases became less clear as the edge was departed from, but no nodal circles of latitude could be detected. The note of this bell is given by the makers as E natural.

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8. *Seismological Work in Japan. By* Professor JOHN MILNE, *F.R.S.*

The first part of this paper was a brief account of work which had been done in Japan. This related to seismometry, the nature of earthquake motion, the making of a seismic survey, the protection of buildings against earthquakes, the vibrations of railway trains, observations on artificially produced disturbances, the work of the Japanese Earthquake Bureau, sea waves, the curvature of volcanoes, earth tremors and their relationship to distant winds, &c.

The second part of the paper dealt with phenomena which were difficult to explain. Amongst these we had the preliminary tremors of an earthquake; the extremely high velocity of earthquake propagation, which even reached 20,000 feet per second; the variation in velocity and period with the intensity of the initial disturbance; or as a disturbance radiated, the relationship between normal and transverse motion, &c.

The last part of the paper treated of observations yet to be made. Amongst other things the author suggested the extension of observations on the velocity of earthquake propagation, such observations possibly leading to the determination of constants representing the rigidity of large rock masses,—continuous observations to determine whether there are changes in the value of J, observations to determine the existence or non-existence of suboceanic land-slides, the establishment of a magnetic observatory on the side of a volcano the lava of which was known to be highly magnetic, observations in a mine beneath the sea to determine the effects of tidal load, tromometric observation in a coal-mining district where there is fire-damp, observations on earth-currents near an active volcano or in connection with large faults, observations on earth oscillations in a district where there is evidence showing that such movements have been rapid. It was shown that there were special reasons for making such observations in a country like Japan.

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9. *On the Vibration of Railway Trains. By* Professor JOHN MILNE, *F.R.S.*

The instrument which the author described consisted of three parts which respectively recorded on a continuously-moving band of paper the vertical, the transverse, and the longitudinal vibratory movements of a railway-carriage or a locomotive.

The most important feature in this instrument was that its action depended upon the existence of 'steady points,' such as we find in modern seismographs, and the writing of the records was *not* dependent upon the movement of bodies having considerable stability like the bob of an ordinary pendulum, such as are found in seismoscopes.

The instrument has worked satisfactorily in Japan, across the American Continent, and on all the lines upon which it has hitherto been tried in England.

The information it gives is as follows:—

1. *For the Traffic Manager.*—It shows *when* a train stopped and for *how long* it stopped, whether at a station, a signal, on the line, or on a siding. It shows where the train went quickly and where it went slowly, &c.

2. *For the Track or Line Inspector.*—It indicates all curves and grades. It shows all abnormal irregularities on a line,—as, for instance, at points and crossings, variations in gauge, want of ballast, springy portions of the road, faults in ties or sleepers, irregular yieldings on bridges, &c.

3. *For the Mechanical Engineer.*—It shows when a locomotive is properly balanced, when it is burning too much coal, &c.

Three types of the instrument have been constructed:—

1. Only recording the vertical component of motion, to time trains, and to give general information respecting the state of a line.

2. Recording all components of motion, to time trains, and to give detailed information respecting the state of a line.

3. Recording all components of motion on a quickly running band of paper, to test locomotives and carriages. With these records each vibration may be analysed separately.

FRIDAY, SEPTEMBER 13.

The following Papers and Reports were read:—

1. *On the Quantity of Deposit of Silver produced by the development on a Photographic Plate in terms of the intensity of Light acting. By* Captain Abney, *C.B., R.E., F.R.S.*

Allusion has already been made in my address as to the law which connects the transparency of deposit on a photographic plate with the intensity of light. In order to investigate the matter further it became necessary to know whether the amount of deposit varied in terms of the intensity of light acting. It was found that it was useless to attempt to weigh the deposit on any reasonable area, and resort had to be made to an artifice to ascertain the fact. The supposition being made that the amount of deposit was proportional to the intensity of light acting, it was evident that if by any means a certain number of particles of silver or other material would be scattered over a given transparent area, then double the number of particles were scattered over an equal area, and so on, that the transparency of the areas should obey the same law as that of the deposit obtained by development, viz. $T' = T\,\zeta^{-\mu x^2}$ where T is the total transparency, T′ the transparency of an area in which x is any power of 2.

Experiments were undertaken to investigate this point. Carbon particles in the shape of Indian ink were suspended in water in such a manner that one amount of water contained double the amount of particles that the next darkest contained, and so on. Bibulous and uniform squares of paper were soaked in these and dried, and the blackness of each three measured, with the result that it was found that the law was obeyed. To add further information to this fact, a gelatine plate was exposed to light and developed, and the film then removed and dissolved up. Of the emulsion thus formed different quantities were taken and added to a plain gelatine solution, the total being made up to a fixed volume. The emulsions were so arranged that one contained double the quantity of particles of the next lightest, and so on. These emulsions were then applied to glass plates of equal area and dried. The transparency of these plates was then measured, and it was found again that the above law was obeyed.

This being the case, it follows that the deposit of silver made by different intensities of light varies directly as the intensity of light acting. This of course within such limits that reversal of the image is not commenced, and that the film is not at any part exhausted of the silver salt which can be reduced.

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2. *On Pin-hole Photography. By* Lord Rayleigh, *LL.D., Sec.R.S.*

In the 'Phil. Mag.' for 1880 it was shown that a simple aperture is as effective as the best possible lens in forming an image, provided only that the focal length (f) is sufficiently great. Conversely, if f be given, the aperture ($2r$) may be made so small that the use of a lens would give no advantage. But if f be such as is usually afforded by a camera, the admissible aperture, being very much less than that of the pupil of the eye, is insufficient for reasonably good definition.

If λ be the wave-length of light, the point at which a lens may be dispensed with is given, viz.

$$f = \frac{2r^2}{\lambda} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

This is the condition that the relative retardation of the rays from the centre and from the margin of the aperture shall amount to $\frac{1}{4}\lambda$. If $2r$ is to be equal to the aperture of the pupil, f would have to be about 66 feet. At this focus and with this aperture the image formed without a lens would be at least as well-defined as that received upon the retina.

In some recent experiments f was about 9 feet, and $2r$ about $\frac{1}{16}$ inch. The specimens exhibited were taken upon gelatine plates, and represent a weather-cock seen against the sky. The amount of detail is not materially less than that observable by direct vision in the case of ordinary eyes. Theoretically, it should correspond to that obtained when the eye is limited to an aperture of $\frac{1}{16}$ inch. If the pictures are held at the ordinary distance of say a foot from the eye, the object is seen under a magnification of nine times, and there is, of course, a corresponding loss of apparent sharpness.

As the focal length increases, the brightness (B) of the image in a properly proportioned pin-hole camera diminishes. For

$$B \propto \frac{r^2}{f^2} \propto \frac{r^2\lambda^2}{r^4} \propto \frac{\lambda^2}{r^2} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

But modern plates are so sensitive that there would be no difficulty in working with an aperture equal to that of the pupil, other than that incurred in providing a focal length of 66 feet with the necessary exclusion of foreign light.

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3. *On Boscovich's Theory.*
By Sir WILLIAM THOMSON, *D.C.L., LL.D., F.R.S.*

Without accepting Boscovich's fundamental doctrine that the ultimate atoms of matter are points endowed each with inertia and with mutual attractions or repulsions dependent on mutual distances, and that all the properties of matter are due to equilibrium of these forces, and to motions, or changes of motion produced by them when they are not balanced, we can learn something towards an understanding of the real molecular structure of matter, and of some of its thermodynamic properties, by consideration of the static and kinetic problems which it suggests. Hooke's exhibition of the forms of crystals by piles of globes, Navier's and Poisson's theory of the elasticity of solids, Maxwell's and Clausius' work in the kinetic theory of gases, and Tait's more recent work on the same subject—all developments of Boscovich's theory pure and simple—amply justify this statement.

Boscovich made it an essential in his theory that at the smallest distances there is repulsion, and at greater distances attraction; ending with infinite repulsion at infinitely small distance, and with attraction according to Newtonian law for all distances for which this law has been proved. He suggested numerous transitions from attraction to repulsion, which he illustrated graphically by a curve —the celebrated Boscovich curve—to explain cohesion, mutual pressure between bodies in contact, chemical affinity, and all possible properties of matter—except heat, which he regarded as a sulphureous essence or virtue. It seems now wonderful that, after so clearly stating his fundamental postulate which included inertia, he did not see inter-molecular motion as a necessary consequence of it, and so discover the kinetic theory of heat for solids, liquids, and gases; and that he only *used* his inertia of the atoms to explain the known phenomena of the inertia of palpable masses, or assemblages of very large numbers of atoms.

It is also wonderful how much towards explaining the crystallography and elasticity of solids, and the thermo-elastic properties of solids, liquids, and gases, we find without assuming more than one transition from attraction to repulsion. Suppose, for instance, the mutual force between two atoms to be repulsive when the distance between them is $<Z$; zero when it is equal Z; and attractive when it is $>Z$; and consider the equilibrium of groups of atoms under these conditions.

A group of two would be in equilibrium at distance Z, and only at this distance. This equilibrium is stable.

A group of three would be in stable equilibrium at the corners of an equilateral triangle, of sides Z; and only in this configuration. There is no other configuration

of equilibrium except with the three in one line. There is one, and there may be more than one, configuration of unstable equilibrium, of the three atoms in one line.

The only configuration of stable equilibrium of four atoms is at the corners of an equilateral tetrahedron of edges Z. There is one, and there may be more than one, configuration of unstable equilibrium of each of the following descriptions:—

(1) Three atoms at the corners of an equilateral triangle, and one at its centre.

(2) The four atoms at the corners of a square.

(3) The four atoms in one line.

There is no other configuration of equilibrium of four atoms, subject to the conditions stated above as to mutual force.

In the oral communication to Section A, important questions as to the equilibrium of groups of five, six, or greater finite numbers of atoms were suggested. They are considered in a communication by the author to the Royal Society of Edinburgh, of July 15, to be published in the 'Proceedings' before the end of the year. The Boscovichian foundation for the elasticity of solids with no inter-molecular vibrations was slightly sketched, in the communication to Section A, as follows.

Every infinite homogeneous assemblage [1] of Boscovich atoms is in equilibrium. So, therefore, is every finite homogeneous assemblage, provided that extraneous forces be applied to all within influential distance of the frontier, equal to the forces which a homogeneous continuation of the assemblage through influential distance beyond the frontier would exert on them. The investigation of these extraneous forces for any given homogeneous assemblage of single atoms—or of groups of atoms as explained below—constitutes the Boscovich equilibrium-theory of elastic solids.

To investigate the equilibrium of a homogeneous assemblage of two or more atoms, imagine, in a homogeneous assemblage of groups of i atoms, all the atoms except one held fixed. This one experiences zero resultant force from all the points corresponding to it in the whole assemblage, since it and they constitute a homogeneous assemblage of single points. Hence it experiences zero resultant force also from all the other $i-1$ assemblages of single points. This condition, fulfilled for each one of the atoms of the compound molecule, clearly suffices for the equilibrium of the assemblage, whether the constituent atoms of the compound molecule are similar or dissimilar.

When all the atoms are similar—that is to say, when the mutual force is the same for the same distance between every pair—it might be supposed that a homogeneous assemblage, to be in equilibrium, must be of single points; but this is not true, as we see synthetically, without reference to the question of stability, by the following examples, of homogeneous assemblages of symmetrical groups of points, with the condition of equilibrium for each when the mutual forces act.

Preliminary.—Consider an equilateral [2] homogeneous assemblage of single points, O, O′, &c. Bisect every line between nearest neighbours by a plane perpendicular to it. These planes divide space into rhombic dodekahedrons. Let A_1OA_5, A_2OA_6, A_3OA_7, A_4OA_8 be the diagonals through the eight trihedral angles of the dodekahedron enclosing O, and let $2a$ be the length of each. Place atoms Q_1, Q_5, Q_2, Q_6, Q_3, Q_7, Q_4, Q_8 on these lines, at equal distances, r, from O; and do likewise for every other point, O′, O″, &c., of the infinite homogeneous assemblage. We thus have, around each point A, four atoms, Q, Q′, Q″, Q‴, contributed by the four dodekahedrons of which trihedral angles are contiguous in A, and fill the space around A. The distance of each of these atoms from A is $a-r$.

Suppose, now, r to be very small. Mutual repulsions of the atoms of the groups of eight around the points O will preponderate. But suppose $a-r$ to be

[1] '*Homogeneous assemblage of points*, or *of groups of points*, or *of bodies*, or *of systems of bodies*,' is an expression which needs no definition, because it speaks for itself unambiguously. The geometrical subject of homogeneous assemblages is treated with perfect simplicity and generality by Bravais, in the *Journal de l'Ecole Polytechnique*, cahier xix., pp. 1–128 (Paris, 1850).

[2] This means such an assemblage as that of the centres of equal globes piled homogeneously, as in the ordinary triangular-based, or square-based, or oblong-rectangle-based pyramids of round shot or of billiard-balls.

very small: mutual repulsions of the atoms of the groups of four around the points A will preponderate. Hence for some value of r between O and a there will be equilibrium. There may, according to the law of force, be more than one value of r between O and a giving equilibrium; but whatever be the law of force, there is a value of r giving *stable* equilibrium, supposing the atoms to be constrained to the lines OA, and the distances r to be constrainedly equal. It is clear from the symmetries around O and around A that neither of these constraints is necessary for mere equilibrium; but without them the equilibrium might be unstable. Thus we have found a homogeneous equilateral distribution of 8-atom groups, in equilibrium. Similarly, by placing atoms on the three diagonals B_1OB_4, B_2OB_5, B_3OB_6, through the six tetrahedral angles of the dodekahedron around O, we find a homogeneous equilateral distribution of 6-atom groups, in equilibrium.

Place now an atom at each point O. The equilibrium will be disturbed in each case, but there will be equilibrium with a different value of r (still between o and a). Thus we have 9-atom groups and 7-atom groups.

Thus, in all, we have found homogeneous distributions of 6-atom, of 7-atom, of 8-atom, and of 9-atom groups, each in equilibrium. Without stopping to look for more complex groups, or for 5-atom or 4-atom groups, we find a homogeneous distribution of 3-atom groups in equilibrium by placing an atom at every point O, and at each of the eight points A_1, A_5, A_2, A_6, A_3, A_7, A_4, A_8. This we see by observing that each of these eight A's is common to four tetrahedrons of A's, and is in the centre of a tetrahedron of O's; because it is a common trihedral corner point of four contiguous dodekahedrons.

Lastly, choosing A_2, A_3, A_4, so that the angles A_1OA_2, A_1OA_3, A_1OA_4 are each obtuse,[1] we make a homogeneous assemblage of 2-atom groups in equilibrium by placing atoms at O, A_1, A_2, A_3, A_4. There are four obvious ways of seeing this as an assemblage of di-atomic groups, one of which is as follows:—Choose A_1 and O as one pair. Through A_2, A_3, A_4 draw lines same-wards parallel to A_1O, and each equal to A_1O. Their ends lie at the centres of neighbouring dodekahedrons, which pair with A_2, A_3, A_4 respectively.

For the Boscovich theory of the elasticity of solids, the consideration of this homogeneous assemblage of double atoms is very important. Remark that every O is at the centre of an equilateral tetrahedron of four O's; and every A is at the centre of an equal, and similar, and same-ways oriented tetrahedron of O's. The corners of each of these tetrahedrons are respectively A and three of its twelve nearest A neighbours; and O and three of its twelve nearest O neighbours. By aid of an illustrative model showing four of the one set of tetrahedrons with their corner atoms painted blue, and one tetrahedron of atoms in their centres, painted red, the mathematical theory which the author had communicated to the Royal Society of Edinburgh was illustrated to Section A.

In this theory it is shown that in an elastic solid constituted by a single homogeneous assemblage of Boscovich atoms, there are in general two different rigidities, n, n_1, and one bulk-modulus, k; between which there is essentially the relation

$$3k = 3n + 2n_1,$$

whatever be the law of force. The law of force may be so adjusted as to make $n_1 = n$; and in this case we have $3k = 5n$, which is Poisson's relation. But no such relation is obligatory when the elastic solid consists of a homogeneous assemblage of double, or triple, or multiple Boscovich atoms. On the contrary, any arbitrarily chosen values may be given to the bulk-modulus and to the rigidity, by proper adjustment of the law of force, even though we take nothing more complex than the homogeneous assemblage of double Boscovich atoms above described.

The most interesting and important part of the subject, the kinetic, was, for want of time, but slightly touched in the communication to Section A. The author hopes to enter on it more fully in a future communication to the Royal Society of Edinburgh.

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[1] This also makes A_2OA_3, A_2OA_4, and A_3OA_4 each obtuse. Each of these six obtuse angles is equal to $180° - \cos^{-1}(\frac{1}{3})$.

4. *On the Determination of 'v' by means of Electric Oscillations.* *By* O. J. Lodge, *F.R.S., and* R. T. Glazebrook, *F.R.S.*

The authors have recently made a determination of *v*, using the oscillatory discharge of a condenser. The period of the discharge, which passed between two terminals connected through a circuit of measured self-induction to an air-condenser of known capacity, was determined by forming an image of the spark on the edge of a rapidly revolving photographic plate, the rate of revolution being accurately ascertained, and examining the record micrometrically.

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5. *On the Instruments used in the recent Magnetic Survey of France.* *By* Professor A. W. Rücker, *M.A., F.R.S.*

A magnetic survey of France has recently been completed by M. T. Moureaux, who has determined the magnetic elements at some seventy stations. A set of instruments similar to those employed by him has recently been made under the supervision of M. Moureaux for the Science Museum at South Kensington, and these were exhibited.

The point aimed at in their construction was to secure accuracy combined with dimensions and weight less than that of the Kew pattern instruments. The weights of the magnetometer and dip circle are only 4 kg. and 2 kg. respectively, and the results published by M. Moureaux show a high degree of accuracy. The main points in the construction of the instruments are: (1) That the needles used are much smaller than those used in the Kew pattern instruments. (2) The end of the declination needle forms a concave mirror, and a reading is taken when the image of a linear mark formed by this mirror is in the prolongation of another line which is exactly opposite to the first on a thin piece of metal. (3) The geographical meridian is determined by a theodolite, which forms part of the apparatus, instead of by using—as in the Kew apparatus—a plane mirror to re ect the image of the sun into a horizontal telescope. (4) Extremely fine silk thr ads are able to support the small magnets used. (5) In the dip circle the graduated arc rotates in its own plane about a horizontal ken when the end of the needle and its image formed by a small concave mirror attached to the graduated circle coincide when viewed through a microscope.

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6. *Report of the Committee on the Molecular Phenomena connected with the Magnetisation of Iron.*—See Reports, p. 33.

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7. *On Magnetic Viscosity in Iron.* *By* Professor J. A. Ewing, *F.R.S.*

The author described experiments showing that in certain circumstances the process is gradual by which iron assumes magnetisation after the imposition of magnetising force. The experiments are set forth in detail in the 'Proceedings of the Royal Society' for June 20, 1889.

SATURDAY, SEPTEMBER 14.

The following Reports and Papers were read:—

1. *First Report of the Committee for considering the possibility of calculating Tables of certain Mathematical Functions, and, if necessary, of taking steps to carry out the calculations and to publish the results in an accessible form.*—See Reports, p. 28.

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2. *On some Formulæ connected with Bessel's Functions.* *By* Dr. MEISSEL.

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3. *On the Relations between Ray-Curvatures, Brachistochrones, and Free Paths.* *By* Professor J. D. EVERETT, *F.R.S.*

In a paper printed in last year's Report (p. 581) I called attention to the fact that a curve which is a free path for a particle under any given law of force is identical with the path of a ray in a medium in which the index μ at each point is proportional to the velocity of the particle. This proportionality must be understood to hold not only at points lying on the orbit itself, but at all neighbouring points, the velocity at a point not on the orbit being interpreted to mean the velocity which the particle would have if guided to this point by frictionless constraint.

On the other hand, the path of a ray is a path of least time, and would therefore be a brachistochrone for a particle subject to forces which, with proper initial velocity, would cause the velocity at each point to be directly as the velocity of light,—in other words, inversely as μ. Thus every curve that would be a ray-path in a medium in which μ is an assigned continuous function of the co-ordinates would also be a free path of a particle for one law of force, and a brachistochrone for another. Also, if we find a second ray-path by giving μ a value proportional to the reciprocal of its previous value, this second curve will be a brachistochrone for the first law of force and a free path for the second. The two curves thus mutually related may be called 'conjugate.'

When μ is a function of distance from a fixed centre, the path of a ray is determined by the equation $\mu p = C$, where p is the perpendicular from the centre on the tangent, and C is constant along any one ray. Let μ be proportional to r^n, r being the distance from the centre, and n any positive exponent. Then by supposing the velocity of a particle to be directly as μ, we find that a force of repulsion from the centre varying as r^{2n-1} will make every ray a free path if the velocity be that due to fall from the centre, and that a force of attraction to the centre varying inversely as r^{2n+1} will make every ray a brachistochrone if the velocity be that due to fall from infinity. The case $n=1$ gives as the conjugate curves the rectangular hyperbola and the equiangular spiral. The cases $n=\frac{1}{2}$, $n=\frac{3}{2}$, $n=3$ give, as one of the conjugate curves, the parabola, the cardioid, and the lemniscate of Bernouilli respectively.

When μ is a function of the distance y from a fixed plane, the value of $\mu \cos \theta$ is constant along any one ray, θ denoting the angle whose tangent is

$$\frac{dy}{dx}.$$

Denoting this constant value by C, we have therefore

$$\left(\frac{dy}{dx}\right)^2 = \left(\frac{\mu}{C}\right)^2 - 1$$

as the differential equation of a ray. Then, by supposing μ to vary first directly and then inversely as y^n, we get a repulsive force varying directly as y^{2n-1} with velocity due to fall from the fixed plane, and attraction inversely as y^{2n+1} with velocity from infinity. The differential equations of the conjugate curves will be

$$\left(\frac{dy}{dx}\right)^2 = \left(\frac{y}{a}\right)^{2n} - 1,$$

and

$$\left(\frac{dy}{dx}\right)^2 = \left(\frac{a}{y}\right)^{2n} - 1.$$

The value $n=1$ gives as conjugate curves the catenary and the circle, the directrix of the catenary and the centre of the circle being in the fixed plane. The case $n=\frac{1}{2}$ gives the parabola and the cycloid, and is applicable to ordinary terrestrial gravity, since it makes the repulsive force constant.

Again, the curvature of both free paths and brachistochrones must follow the

same rule as the curvature of rays; that is to say, its value at each point must be equal to the rate at which the logarithm of the velocity changes as we travel along the principal normal. For a free path the velocity increases inwards, and for a brachistochrone outwards.

The following proof of this law of ray-curvature rests on the physical principle that rays from a point are cut orthogonally by surfaces of equal time.

Let T denote the time light takes to travel from a given fixed point to any point. Then, if ds be measured along a ray, we have for the difference of time to its two ends

$$dT = \frac{ds}{v},$$

v denoting the velocity of light; and if dx be measured at an inclination a to a ray, the difference of time to its two ends is

$$dT = \frac{dx \cos a}{v}.$$

Hence

$$\frac{dT}{dx} = \frac{\cos a}{v},$$

and similarly

$$\frac{dT}{dy} = \frac{\sin a}{v}$$

Therefore

$$\frac{d}{dy}\frac{\cos a}{v} = \frac{d}{dx}\frac{\sin a}{v}.$$

Performing the differentiations indicated in this last equation, and then putting $a=0$, so that the axis of x is tangential and the axis of y normal, we have

$$\frac{da}{dx} = -\frac{1}{v}\frac{dv}{dy} = -\frac{d}{dy}\log v = \frac{d}{dy}\log \mu;$$

where $\frac{da}{dx}$ is the curvature $\frac{1}{\rho}$, and $\frac{d}{dy}$ expresses rate of variation along the normal.

Several of the foregoing results have been previously obtained by the employment of Maupertuis' principle of Least Action; but to many students the optical proofs here given will be more intelligible.

Reference may be made to a special method of deducing brachistochrones from free paths by Professor Townsend ('Quart. Journ. Math.' vol. xiv.), and to a paper by Professor Larmor on Least Action ('Proc. Lond. Math. Soc.' vol. xv.).

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4. *On Curves in Space.* *By* Professor Cayley, *F.R.S.*

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5. *On the Extension and Bending of Cylindrical Shells.* *By* A. B. Basset, *M.A.*, *F.R.S.*

The recent investigations of Lord Rayleigh[1] and Mr. Love[2] have directed attention to this subject, and I propose in the present paper to discuss two points connected with this question.

The potential energy of a shell of thickness h consists of two terms, one of which is proportional to h, and depends upon the stretching of the middle surface, whilst the other, which is proportional to h^3, depends upon the bending. The theory which has been adopted by most English writers upon the vibrations of thin shells, supposes that the energy due to bending is the most important, and that the

[1] *Proc. Roy. Soc.*, vol. xlv., pp. 105 and 443.
[2] *Phil. Trans.*, 1888, p. 491; and *Proc. Lond. Math. Soc.*, vol. xx., p. 89.

term due to stretching is negligible in comparison with the former. Mr. Love, on the other hand, considers that the term due to stretching is of greater, or at any rate of equal importance to that due to bending, and also that it is impossible to satisfy the conditions at a free edge, if the shell vibrates in such a manner that every line on the middle surface is unaltered in length.

For the purpose of examining the theory proposed by Mr. Love, I think it will be best to avoid for the present making any assumption as to the relative importance of the two terms of the potential energy, and to retain them both; and I shall therefore in the first place consider the equilibrium of an indefinitely long cylindrical trough filled with liquid of density ρ, whose cross section is a semicircle of radius a, and which is supported by vertical strings attached to its edges.

Putting

$$E=\frac{8mnh}{(m+n)a},$$

I find that the extension is constant and equal to $g\rho\pi a/4E$, and that the change of curvature is

$$\frac{1}{\rho_1}-\frac{1}{a}=\frac{3g\rho a^2}{2Eh^2}\left[\tfrac{1}{2}\pi-(\tfrac{1}{2}\pi-\phi)\cos\phi-\sin\phi\right] \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where ϕ is measured from either of the edges. We therefore see that the change of curvature vanishes at both the edges.

If W_1 be the potential energy per unit of area due to bending, and W_2 the corresponding quantity due to stretching,

$$\left(\frac{W_1}{W_2}\right)^{\frac{1}{2}}=\frac{2a\sqrt{3}}{\pi h}\left\{\tfrac{1}{2}\pi-(\tfrac{1}{2}\pi-\phi)\cos\phi-\sin\phi\right\} \quad . \quad . \quad . \quad . \quad . \quad (2)$$

Since h is small in comparison with a, we see that W_1 is large compared with W_2, except in the neighbourhood of the two edges.

In the preceding problem it is evident that the middle surface must be subjected to a considerable strain, owing to the fact that the shell has to support the weight of the whole of the liquid which it contains; and it seems hardly probable that when vibrations are set up by striking a cylindrical shell a greater extension of the middle surface is thereby produced than in the statical problem just considered. I therefore think we are justified in concluding that in the case of metal shells the bending term is the most important. It would not, however, be safe to apply this conclusion without further investigation of the case of indiarubber shells, under the influence of external pressure, inasmuch as the potential energy due to the contraction of the thickness might have to be taken account of.

Mr. Love has also raised the objection that when a cylinder is vibrating it is impossible to satisfy the conditions at a free edge if the middle surface is supposed to be inextensible. We shall now, for the purpose of examining this objection, consider the vibrations of an indefinitely long circular cylinder, when the displacement of every point lies in a plane perpendicular to the axis.

If we omit the stretching terms and also the terms due to the rotatory inertia, the equation of motion is

$$\frac{Eh^2}{3a^3}\left(\frac{d^3\lambda}{d\phi^3}+\frac{d\lambda}{d\phi}\right)+2\rho h\frac{d^2}{dt^2}\left(v-\frac{d^2v}{d\phi^2}\right)=0 \quad . \quad . \quad . \quad . \quad . \quad (3)$$

where

$$-\lambda=\frac{d^3v}{d\phi^3}+\frac{dv}{d\phi};$$

and if the cross section of the cylinder is an arc of a circle of length $2a\alpha$, the conditions to be satisfied at the two generating lines which form the edges of the shell are

$$\lambda=0 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

$$\frac{d\lambda}{d\phi}=0 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

$$\frac{Eh^2}{3a^3}\left(\frac{d^2\lambda}{d\phi^2}+\lambda\right)-2\rho h\frac{d^3v}{d\phi dt^2}=0 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

The total stress across any section made by a plane passing through a generating line consists of a couple, a normal shearing stress, and a tension perpendicular to the generating line;[1] and equations (4), (5), and (6) are the conditions that these stresses should vanish at a free edge.

In order to solve these equations, we must assume that v varies as $\epsilon^{\iota(s\phi+pt)}$. Substituting in (3), we find that the relation between s and p is

$$p^2=\frac{4mnh^2s^2(s^2-1)^2}{3(m+n)(s^2+1)\rho a^4} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

The value of s in terms of p are the six roots of (7), but in order to obtain the frequency, the value of s in terms of the dimensions and elastic constants is required. Now each of the boundary conditions must be satisfied at each of the two edges of the shell, and therefore there are altogether six equations of condition. Hence the six constants which appear in the solution of (3) can be eliminated, and the resulting determinantal equation combined with (7) will give the frequency.

If the cylinder is complete, s is an integer, and the frequency is determined by (7), which is the result obtained by Hoppe and Lord Rayleigh.

If a cylindrical shell of finite length is bent along a generating line in such a manner that its curvature is increased, all lines parallel to the axis which lie on the convex side of the middle surface will be contracted, whilst all such lines which lie on the concave side will be extended, and this contraction and extension will give rise to a couple about the circular sections which tends to produce anticlastic curvature of the generating lines. One of the boundary conditions requires that this couple should vanish at the two circular edges; and consequently the preceding investigation does not apply when the cylinder is of finite length.

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6. *Simplified Proofs (after Euler) of the Binomial Theorem* (i.) *for any Positive Fractional Exponent;* (ii.) *for any Negative Exponent. By* T. WOODCOCK, M.A.

(i.) We assume the theorem proved for any positive integral exponent.

Let h and k be positive integers throughout, and let x be numerically less than unity, so that the series occurring are convergent.

Since

$$\{(1+x)^m\}^k=(1+x)^{mk};$$

therefore the kth power of

$$1+mx+\frac{m(m-1)}{1.2}x^2+\ . \ . \ . \ .$$

is always

$$1+mkx+\frac{mk(mk-1)}{1.2}x^2+\ . \ . \ . \ .$$

when m is a positive *integer*; therefore, also, when m is a positive *fraction* [since the form of the said kth power cannot be affected by m being integral or fractional].

Let $m=\frac{h}{k}$, then $mk=h$;

$$\therefore\left\{1+\frac{h}{k}x+\frac{\frac{h}{k}\left(\frac{h}{k}-1\right)}{1.2}x^2+\ . \ . \ . \ .\right\}^k=1+hx+\frac{h(h-1)}{1.2}x^2+\ . \ . \ . \ .$$

that is $(1+x)^h$, since h is a positive integer.

[1] Compare Besant, 'On the Equilibrium of a Bent Lamina,' *Quart. Journ.*, 1860.

Therefore

$$1+\frac{h}{k}x+\frac{\frac{h}{k}\left(\frac{h}{k}-1\right)}{1.2}x^2+\ \ldots\ldots$$

is one of the values of $(1+x)^{\frac{h}{k}}$.

(ii.) We now assume the theorem proved for any positive exponent. Let n be positive throughout, and, as before, let x be numerically less than unity.

Since

$$(1+x)^m.(1+x)^n=(1+x)^{m+n};$$

therefore the product of

$$1+mx+\frac{m(m-1)}{1.2}x^2+\ \ldots\ldots \text{ and } 1+nx+\frac{n(n-1)}{1.2}x^2+\ \ldots\ldots$$

is always

$$1+(m+n)x+\frac{(m+n)(m+n-1)}{1.2}x^2+\ \ldots$$

when m is *positive*; therefore, also, when m is *negative*.

Let $m=-n$; then

$$\left(1+(-n)x+\frac{-n(-n-1)}{1.2}x^2+\ \ldots\ldots\right)(1+x)^n=1;$$

therefore

$$1+(-n)x+\frac{-n(-n-1)}{1.2}x^2+\ \ldots\ldots=\frac{1}{(1+x)^n}=(1+x)^{-n}.$$

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7. *On the Extensibility of Liquid Films.* *By* Lord Rayleigh, *LL.D., Sec.R.S.*

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8. *On Hysteresis in the relation of Strain to Stress.* *By* Professor J. A. Ewing, *F.R.S.*

It is now well known that when an iron wire is subjected to the alternate application and removal of tensile stress, many times repeated, certain of its qualities which are affected by the changes of stress exhibit hysteresis with regard to the changes of stress. If the load is cyclically varied between definite limits these qualities do not have the same values at corresponding intermediate points during the application and removal of load; there is a hysteresis or lagging in the change of quality which in some cases appears to be of a static character—that is to say, to be independent of the time-rate of variation of stress. Conspicuous instances of this action are seen in the changes of magnetic and thermo-electric qualities under changes of stress, some of which have been described by the author in former papers.[1]

It is natural to look for an effect of the same kind in the extension and retraction which the wire undergoes. We should expect that, after the change of loads has been frequently repeated so that a cyclic *régime* is established, the wire will, for any value of load intermediate between the two extremes, be longer during unloading than during loading. Evidently, if such an effect exist, it must be small, as it is well known that the proportionality of strain to stress which is expressed by Hooke's law is at least approximately exact.

Sir W. Thomson's experiments on the damping of torsional vibrators have long ago shown that an action of the kind spoken of occurs in quickly performed cycles of torsional strain. But it does not seem to have been looked for in slow cycles of longitudinal pull.

[1] *Phil. Trans. Roy. Soc.* 1885, 1886.

The author has, with the assistance of one of his students, Mr. D. Low, looked for the effect in question and has found it, not only in iron but in steel, brass, and copper wires. He has not yet examined other metals.

The experiment consisted in observing, with much optical magnification, the extension of a very long piece of wire, directly loaded with lead weights. The wire was hung from a rigid support in a testing flue or recess, built in the wall of the laboratory, and extending up through four storeys. At a distance of 806 cms. below the top a small clamp was fixed on the wire, and this formed the support of the back foot of a little tripod, the feet of which consisted of three needle points about an inch apart. The two front feet rested in a slot and hole in a fixed shelf which stood in front of the long wire. The tripod carried a plane mirror which became tilted forward or backward as the wire extended or retracted. Readings were taken by a telescope of the reflected scale of a levelling staff placed vertically at a distance of some 5 metres from the mirror. The staff was graduated to $\frac{1}{100}$th of a foot, and it was easy to read by estimation to $\frac{1}{1000}$th of a foot, which corresponded to 0·000000102 of the length of the wire. At first a fixed shelf was used to support the two front feet of the mirror, but the effects of temperature were found to be excessive, although the greatest care was taken to shield the wire from draughts; and the plan was resorted to of hanging the shelf from two adjacent wires of the same material, suspended from the same support as the wire which was to be stretched.

In this form the method of optical multiplication was nearly the same as one used by Mr. Bottomley in recent experiments on the extension of loaded wires by heat.[1]

The first wire tested was of iron, in the hard-drawn state, 1·08 mm. in diameter. A weight of 14 lbs. was kept permanently on it, and an additional weight of 20 kilos. was applied and removed many times. Then readings were taken at intermediate loads (the extreme load caused so much tilting of the mirror that readings could not be taken throughout the whole range). At 10 kilos. (the middle of the cycle) on the way up the scale reading was 2,340; with the same weight on the way down it was 2,305. The difference, due to hysteresis, is 35, or 0·00000357 of the length. The whole extension per kilo. was 533 scale divisions, so that the change of length due to the full load of 20 kilos. was $20 \times 533 = 10{,}660$ scale divisions. Hence the amount of difference in length at the middle position, namely at 10 kilos., in the loading and unloading processes was $\frac{35}{10660}$, or, say, $\frac{1}{300}$th of the whole extension between the extreme load. Another way of stating the result would be to say that the extension had the same value at 10·066 kilos., while the load was being increased, as it had at 10 kilos., while the load was being diminished: the effect of hysteresis is equivalent to a difference of 66 grammes in the load.

Further experiments were made to test how far this hysteresis depends on the time rate of loading and unloading. In the above case, the cycle of load had been performed as quickly as was practicable, the only pauses being at 10 kilos. on the way up, and at 10 kilos. on the way down. It was found that even when the pause at 10 kilos. lasted for two hours no distinct change took place in the readings. So far as this experiment showed, the hysteresis is persistent. It appeared, however, that pauses at the extremes of load have the effect of increasing the difference of readings at the middle. In a slowly performed cycle where a pause of about three minutes was allowed at each step (of 2 kilos.) in the processes of loading and unloading, the difference of the readings at 10 kilos. was about 50 scale divisions instead of the 35 divisions observed in the former case.

A similar trial was made with mild steel wire, previously annealed and then hardened by the imposition of a load much greater than the load afterwards used in the testing cycle. Here the wire was 0·94 mm. in diameter. There was, as in the former case, a constant load of 14 lbs., and the cycle was made by applying and removing 12 kilos. At 6 kilos. the readings were 4,695 and 4,726. Difference 31. The extension per kilo. was 750. Hence the hysteresis is $\frac{31}{12 \times 750} = \frac{1}{290}$ of the

[1] *Phil. Mag.* August 1889.

extension due to the whole load. With long pauses at the middle load the hysteresis appeared to be reduced to 27 scale divisions, or $\frac{1}{333}$ of the whole extension.

Next, a hard wire of high carbon steel was tested, 0·72 mm. in diameter, by having 14 lbs. permanently on, and loading and unloading 12 kilos. At 6 kilos. the readings were:—'up' 9,220, creeping to 9,240 in two hours; 'down' 9,400, creeping to 9,370 in two hours. Differences 180 and 130.

The extension for 1 kilo. was 1,290, so that the above differences correspond to $\frac{1}{86}$th and $\frac{1}{119}$th of the whole extension respectively. It is remarkable that the hysteresis is decidedly greater here than in the wires previously tested.

A brass wire 1·08 mm. in diameter tested in the same way with 12 kilos. gave readings 6,990 and 7,114 at 6 kilos., difference = 124, which was equivalent to $\frac{1}{107}$th of the whole extension, since the extension for 1 kilo. was 1,100 scale divisions.

With a copper wire 1·15 mm. in diameter, loaded with 10 kilos., the readings at 5 kilos. showed a difference of 52 scale divisions, equivalent to $\frac{1}{150}$th of the whole extension.

These experiments make it clear that in conditions of loading such as those they deal with, there is a decided departure from Hooke's law, one effect of which is that some work is done upon the material when it is put through a cycle of stress changes. If the relation of strain to stress were represented graphically, the curves would form loops enclosing a certain area. This result has a sufficiently obvious bearing on the conclusions of Wöhler with regard to the deteriorating effect of repeated variations of stress.

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9. *On the relation of the Ether to Space.* *By* Dr. G. JOHNSTONE STONEY, *F.R.S.*

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10. *On the E.M.F. produced by an Abrupt Variation of Temperature at the point of contact of two portions of the same Metal.* *By* Professor HENRY STROUD, *M.A.*, *D.Sc.*

The results of experiments on the E. M. F. produced when two portions of the same metal are in contact, and one portion is *kept* at a high temperature and the other at a low temperature, can be predicted from the thermo-electric diagram, and conversely a simple and direct method may thus be obtained for the determination of the Thomson effect. The precautions necessary in the performance of such experiments are discussed in the paper, and the results obtained are given in the case of copper and iron, two typical metals. The E. M. F. established in the case of copper is from hot to cold across the junction, while in the case of iron it is from cold to hot and of far greater magnitude.

These experiments are being continued with a view to obtaining the relation between the E. M. F. and the difference of temperature.

MONDAY, SEPTEMBER 16.

The following Reports and Papers were read:—

1. *Fourth Report of the Committee for inviting Designs for a good Differential Gravity Meter.*

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2. *Report of the Committee for the Collection and Identification of Meteoric Dust.*—See Reports, p. 34.

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3. *Fifth Report of the Committee for considering the best methods of recording the direct Intensity of Solar Radiation.*—See Reports, p. 40.

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4. *On the Black Bulb Thermometer in Vacuo.*
By Professor HERBERT M'LEOD, *F.R.S.*

This instrument, which is generally employed for measuring solar radiation, does not appear to give universal satisfaction, for it is said that no two instruments give the same result when placed side by side. No doubt the imperfection of the vacuum may account for this in a great measure, but besides this there appear to be other causes.

When such an instrument is exposed to the rays of the sun a large proportion of the radiation passes through the enclosing case, and also traverses the opposite side of the globe. Some, however, is absorbed by the blackened thermometer bulb, and this then begins to radiate heat of low refrangibility which is incapable of passing through the enclosing case; as a consequence the latter becomes heated, so that the thermometer bulb is in a warmer enclosure than at first. The quantity of heat thus radiated will be diminished the smaller the bulb of the thermometer, and some years ago I suggested to Mr. Hicks to make a thermometer with a very small bulb. Such a one was made, and I am informed that it gave readings ten degrees *higher* than any other instrument. As this was exactly opposite to my expectation, perhaps I may be excused for not attempting any explanation. Some months ago I ordered two instruments with very small bulbs, one to be in a thick case and the other in a thin one. When the instruments came I found that one of the cases, which appeared the thicker, was devitrified and rough, and produced a very marked shadow when held before a screen exposed to sunshine, so I was not surprised to find that this thermometer always indicated a slightly lower temperature than the one with the clear glass. It was returned to the maker, and I was then informed that the bulb was a thin one, and the devitrification was caused by blowing the bulb before the lamp. This, therefore, supported the theory that I had formed on the subject. These two thermometers were used from May 20 to June 6. The mean of the readings of the instrument in the thick case was 119·2° F., and the mean obtained by the instrument in the thin case was 116·8°. I then had one of the thermometers enclosed in a case of very thick glass. The thermometers were then tested with a thermopile, to determine the quantity of radiant heat that would pass through the enclosing cases. The source of heat was an albo-carbon flame, and the cases of the thermometers were interposed in succession between the flame and the cone of the thermopile.

Case of thermometer with large bulb transmitted about 26 per cent. of the radiant heat.

Thin case of thermometer with small bulb transmitted about 23 per cent. of the radiant heat.

Thick case of thermometer with small bulb transmitted $11\frac{1}{4}$ per cent. of the radiant heat.

These thermometers were exposed to the sun's rays for the first 27 days of August, and the means of the readings are as follow:—

Large bulb instrument	125·7° F.
Small bulb with thin case	119·9 ,,
Small bulb with thick case	118·3 ,,

Although the case of the instrument with the large bulb allowed a larger percentage of the rays from a low temperature source to pass through, yet the amount of heat radiated from the large bulb was so great that the case was warmed sufficiently to cause the instrument to read, on the average, nearly 6° F. higher than the small bulb instrument. It should be noted, however, that the small bulbs are not so dead black as the large bulb, which is coated with lampblack, the small bulbs being made of black glass.

According to the theory enunciated above, the thermometer with the thick

case should have read higher than the one with the thin case; it, however, gave readings 1·6° F. lower. But it must be remembered that the thick case transmitted less than half as much of the radiation from the gas flame as passed through the thin case, so it must have stopped more of the radiation from the sun than the thin case, and notwithstanding this the temperature registered is very little less than that indicated by the other instrument.

The small bulb instrument has another advantage over the large bulb one, inasmuch as it is much more sensitive, and so reaches the maximum more quickly than when a large bulb is used. This is shown by the readings on August 4, when there were only some occasional gleams of sunshine, the large bulb registering 98·2° F. and the small bulb 101·8° F.

It seems to follow from these experiments that the black bulb should be as small as possible, and very little of the stem blackened; and also that the case should be as thin as is consistent with strength.

A series of experiments should be carried out with instruments of different sizes and with cases of different thickness in order to set the matter at rest. Some investigations on this subject have been carried on at the Kew Observatory, but I believe they have been only partially published. An accident to our old instruments gave me the opportunity of having fresh ones constructed, and it seemed advisable to put the above results on record.

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5. *Fifth Report of the Committee for considering the best means of Comparing and Reducing Magnetic Observations.*—See Reports, p. 49.

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6. *On Atmospheric Electricity. By* Professor LEONHARD WEBER.

The continuous currents obtained on clear days by flying kites and balloons were investigated, and deductions as to the rate of variation of potential with elevation were made.

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7. *Electrification of Air by Combustion.*[1] *By* MAGNUS MACLEAN, *M.A., F.R.S.E., and* MAKITA GOTO.

This was a description of a large series of experiments on natural atmospheric electricity carried on, under the instructions of Sir W. Thomson, in several of the rooms of the University of Glasgow. Their purpose was to find a relation between the electrification of the air within a room, and the potential of the air in its neighbourhood outside; and also the causes which produce or change the electrification of air within an enclosed space.

An insulated water-dropper and a Thomson's quadrant electrometer were used in the usual manner, but the deflections were observed by a telescope instead of by lamp. It was found that an enclosed mass of air is electrified negatively by the burning of a paraffin lamp, of coal gas, of sulphur, of magnesium, and of several other substances. On the other hand, the burning of charcoal electrified a room positively.

An arrangement was also described by means of which the burning substance was joined metallically to one of the quadrants of the electrometer, and precautions being taken to guard against the effect of the surrounding air, it was found that the substances which electrified the air negatively became positively electrified themselves. Thus burning charcoal was found to give a deflection equivalent to three volts in the negative direction, the other terminal of the electrometer being joined to the case of the instrument and to earth.

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[1] *Electrician*, September 20, 1889.

8. *Notes on Atmospheric Electricity and the use of Sir William Thomson's portable Electrometer in the Tropics. By* Professor C. MICHIE SMITH.

Recent observations fully confirm the author's previous conclusions, that in Madras, with a dry west wind, the potential of the air for some distance above the ground is usually negative. This seems always to be associated with dusty air. The potential of the air remains positive till between 9 and 10 a.m., then becomes negative, and continues so till the sea breeze sets in. Electrometer observations on evenings when sheet lightning is seen point to the conclusion that, while much so-called sheet lightning is really simply the reflection of distant flashes, it is more often due to discharge taking place between two neighbouring clouds. In this case the electrometer is unaffected, whereas it is strongly influenced by the discharges of a distant storm. This conclusion is strongly confirmed by other observations. Two series of observations made in Japan were then described; one made during the ascent and descent of the active volcano of Asamayama, the other in crossing the Wada Pass.

In using the portable electrometer in hot moist climates, special precautions have to be taken in drying it. As much sulphuric acid must be used as the pumice can absorb, and the pumice should be dried at least once a fortnight. The charging rod itself must be very carefully dried, and after charging should be lifted out with a piece of warm silk.

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9. *On Photographs of Lightning. By* Professor LEONHARD WEBER.

Two photographs obtained with an oscillating camera were exhibited; the peculiarities of the pictures were described, and conclusions were drawn from them.

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10. *On Dark Flashes of Lightning. By* A. W. CLAYDEN, *M.A.*

The author exhibited a negative taken June 6th, 1889, which shows several reversed images of lightning flashes. He described a series of experiments which he had carried out with the object of discovering whether the phenomenon could be imitated in the laboratory. The steps in the investigation were illustrated by a series of negatives showing photographs of electric sparks.

The conclusions arrived at are that photographic images of electric sparks can be reversed by the action of diffused light. Reversal is only produced when the exposure to diffused light is subsequent to (or possibly simultaneous with) exposure to the image of the spark. If the plate is first acted on by diffused light, the sparks give a direct image unless the action has been considerable, in which case they seem to make no impression.

If the plate is exposed to sparks in one direction, then to diffused light, and again to sparks in some other direction, the first set of sparks show reversal, while the images of the second set will be direct. This explains the crossing of a 'dark flash' by a bright one.

When the image of the spark is dense, reversal begins on the margin and works inwards towards the denser core, and the more brilliant the sparks the greater the exposure to diffused light required for reversal. This, in turn, explains the reversal of comparatively faint branches of a flash, while the principal line of discharge gives a direct image.

The reversing-light may be either gas-light, that from a paraffin lamp, lime light, magnesium-light, daylight, or even the diffused light of electric sparks. In the last case, reversal is more easily produced if the light passes through ground glass, or is reflected from a white surface, than if it is allowed to fail directly on the plate.

The explanation of these photographic phenomena is obscure. The intensity of the light does not seem to have anything to do with the matter, except that the effects of the spark and reversing light must be about equal. Nor does the refrangibility of the reversing light offer an explanation, for the reversing power is apparently proportional to the actinic power.

The author is pursuing the research.

11. *Report of the Committee appointed to co-operate with the Scottish Meteorological Society in making Meteorological Observations on Ben Nevis.*—See Reports, p. 315.

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12. *The Determination of the Amount of Rainfall.*[1] *By* Professor CLEVELAND ABBE.

A résumé of the general results of investigations on this subject was given.

The deficit in catch by a gauge due to eddies of wind was shown on general reasoning to be proportional to the velocity of the wind, and to the relative percentage of small and slowly falling drops.

Examination of the result, for many years at many places in the United States and Western Europe, gives :—Average percentage deficiency = 6 times the square root of the elevation of the gauge measured in metres. Combined with Archibald and Stevenson's result, that for small altitude the wind-velocity is proportional to the square root of the altitude, this confirms the conclusion that the deficiency is proportional to the wind-velocity.

Instead of using the coefficient 6 which is deduced from averages, it is better to use two gauges at different heights; then if c is the catch by a gauge, P the catch by a normal pit-gauge, h the altitude of the mouth of the gauge, k the unknown coefficient to be used instead of 6, the above law gives

$$c = \mathrm{P}\,(1 - k\sqrt{h})\,;$$

and if c_1, c_2 are the simultaneous catches of the gauges at altitudes h_1, h_2, the real rainfall is

$$\mathrm{P} = c_1 + \frac{c_1 - c_2}{\sqrt{h_2/h_1} - 1}.$$

The correction thus introduced is comparable with the differences on which climatologists have had so much discussion, viz., as to the effects of forests, buildings, time of day, cultivation of land, sunspots, &c.

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13. *Hygrometry in the 'Meteorological Journal.'* *By* C. PIAZZI SMYTH.

After noting the superior value officially attached to determinations of the mean temperature by observations of self-registering thermometers, recording its maximum and minimum every twenty-four hours, the author inquires why the still more difficult problem of ascertaining the mean daily moisture of the atmosphere is thrown over to a different principle of observing, long since condemned for simple temperature.

Believing that the want of good self-registering dry- and wet-bulb thermometers for the purpose, was the chief obstacle, and having alighted on some recent makes of Sixe's thermometers with their usual maximum and minimum registrations, as well as several other very recommendable qualities, he invested two out of four of them with the peculiar fittings for wet-bulb hygrometers, after having made a table of index corrections for them all, as dry thermometers, compared with a standard thermometer.

But as soon as hygrometric observations began, the depression of the wet, below the dry, bulb always came out at only two-thirds of what a standard but non-registering Glaisher arrangement gave out, for the horizontal form of Sixe; and no more than half, for a vertical form.

These differences of hygrometric statement, though rather puzzling for a time, were traced up to the wet-bulbs of the Sixe's thermometers being in contact on one side with the scale-plate. For when that plate in the horizontal Sixe form was cut entirely away from the bulb, and a new vertical form of Sixe was made (per Mr. James Bryson, Edinburgh) with its long thin bulb wholly outside the rest of the instrument, the indications of all three varieties of wet-bulb hygro-

[1] *American Meteorological Journal*, vol. vi. 1889, pp. 241–248.

meters became practically the same; and hygrometry was relieved of the old drawback on its non-registrations of maximum and minimum quantities of moisture in every twenty-four hours.

14. *Eighteenth Report of the Committee on Underground Temperature.* See Reports, p. 35.

15. *Second Report of the Committee appointed to arrange an investigation of the Seasonal Variations of Temperature in Lakes, Rivers, and Estuaries in various parts of the United Kingdom.*—See Reports, p. 44.

16. *On the Temperature of the Tidal Estuaries of the South-east of England.* *By* H. C. Sorby, *LL.D., F.R.S.*[1]

The observations made by the author on his yacht 'Glimpse' during the summer months of 1884–88 have been discussed for the Committee on Seasonal Variations of Temperature in Estuaries, &c. The estuaries examined were all those lying between the Strait of Dover and Lowestoft; their depth averaged from 1½ to 4 fathoms. Observations were at the same time made on the stretch of more open water into which these estuaries open; this had an average depth of 6 fathoms. Temperature was observed both at surface and bottom, but the difference between the two was usually slight. The mean results for the five years 1884–88 are as follows:—

Month	Estuaries		Open water	Air
	High tide	Low tide		
May	54·18	55·48	51·80	55·39
June	60·77	61·48	60·24	60·14
July	65·67	66·44	64·18	65·07
August	64·03	64·25	63·36	64·28
September	61·00	60·58	61·30	60·51
Mean	61·13	61·64	60·18	61·08

The excess or defect of temperature at low water varied in each year, but the low-tide temperature was higher, except in September and sometimes in May, showing that the landward water responded more quickly to the change of the seasons and had a greater range of temperature than that of the more open sea. The diurnal range of temperature in the water came to a maximum in July and then decreased. During the months under consideration the increase of temperature by the day's heating was found to be 1·07° at high water and 1·71° at low water; the fall of temperature produced by the night's cooling 0·76° at high water and 1·50° at low water. This shows that the depth of the estuary and the relatively large proportion of river water are the chief factors in determining the effect of radiation on water temperature.

17. *Apparatus for reading Indications of distant Meteorological Instruments.* *By* T. J. Murday.

18. *On the Periodical Return of Storms.* *By* T. J. Murday.

In this paper the author dealt with the subject of recurring periods, and by means of charts and tables of storm cycles demonstrated the fact that certain (if

[1] Published *in extenso* in the *Scotch Geographical Magazine.*

not all) primary areas of depression have regular periods of return. He gave the periods of many of the great storms that have affected the British Islands during the last few years, and traced the intensity and position of the disturbances at each date of recurrence, back to the year 1880.

19. *On the Periodicity of Mild Winters.* *By* R. E. W. Goodridge.

The author said that observations in Manitoba confirmed Dr. Schuster's conclusions ('British Association Report,' 1884) of an eleven-year period in the occurrence of mild winters.

TUESDAY, SEPTEMBER 17.

The following Papers and Reports were read:—

1. *Some Experiments on Radiation with Professor Hertz' Mirrors.* *By* F. T. Trouton.

2. *Report of the Committee for constructing and issuing Practical Standards for use in Electrical Measurements.*—See Reports, p. 41.

3. *Fourth Report of the Committee on Electrolysis.*—See Reports, p. 223.

4. *Report on the present State of our Knowledge in Electrolysis and Electrochemistry.* *By* W. N. Shaw, *M.A.*[1]

5. *The Passage of Electricity through Gases.* *By* Professor Arthur Schuster, *F.R.S.*

The author has, during the last two years, investigated the distribution of potential in the neighbourhood of the negative pole of discharge of electricity through rarified gases. Knowing the rate of fall of potential it can be determined whether there is any bodily electrification in any part of the negative glow. It was found that the kathode is surrounded by an atmosphere of positively electrified gaseous particles extending to the outer edge of the so-called dark space.

According to the author's views this atmosphere corresponds to the polarised layer adjoining the negative electrode in an electrolyte. The cause of the sudden difference in luminosity between the dark space and the negative glow has also been investigated and it has been found that the negative particles projected from the kathode pass unhindered through the dark space while their velocity is quickly reduced in the glow proper, the translatory energy being thus changed into energy of vibration.

6. *On the Discharge of Electrification by Flames.* *By* A. M. Worthington.—See Reports, p. 225.

7. *On the Failure of Metal Sheets to screen off the Electrostatic Action of a Moving or Varying Charge.* *By* Professor Oliver J. Lodge, *F.R.S.*

Experiments have been made on the screening effect of a very thin film of silver chemically deposited, the thickness of the deposit being different in the different

[1] At the author's request, this report is held over until next year.

experiments; the test applied being a microscopic deflection of a sort of electrometer needle suspended inside a coated glass beaker. A charged body in the neighbourhood is suddenly discharged or reversed, or else rapidly moved. The coat of silver on the beaker is found to protect only so long as it is opaque; it no longer does so when the deposit is thin enough to be transparent.

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8. *On a new Form of Current-Weigher.* *By* Professor JAMES BLYTH, *M.A.*, *F.R.S.E.*

In the construction of balances for the measurement of electric currents a greater or less difficulty has always been experienced in leading the current into the movable parts of the instrument without seriously interfering with its sensibility. Several methods have been adopted to overcome this difficulty. In some balances the current is led in by mercury cups; in others, flexible leads, made of thin wire spirals or thin metal strips, are employed; while, in the recent balances by Sir William Thomson, the difficulty has been overcome by means of his well-known ligature suspension.

Some time ago it occurred to me that still another form of balance might be employed for this purpose, and the present paper is a short description of one which I have made.

The balance referred to is of the ordinary Roberval type, with the pivot connections all replaced by tightly-stretched torsion wires.

It is constructed as follows:—

On a flat base-board are placed two vertical uprights of wood or other insulating material, about 6 inches apart. Between these are stretched two parallel wires in the same vertical plane about 3 inches apart. To the middle points of these wires are soldered the two horizontal metal bars of the Roberval.

These are about 9 inches long. Both horizontal bars terminate at each end either in forks or rings, placed in a horizontal plane, and wires are tightly stretched between the prongs of the forks, or across a diameter of the rings. To the middle points of these last wires are attached, also by soldering, the vertical bars of the balance, thus completing what takes the place of the ordinary jointed parallelogram of the Roberval.

The vertical bars have metal terminals, insulated from each other, and carry the circular discs, on the rims of which the movable coils of wire are wound. The bars pass at right angles through the centres of the discs, and are fixed to them at their middle points. The fixed coils, which are of exactly the same diameter as the movable ones, are supported from the base-board, and are placed so that one is about half an inch above one movable coil, while the other is as much below the other movable coil. From this it will be seen that when the balance is in equilibrium the fixed and movable coils are all horizontal, with a space of about half an inch between each pair.

The stretched wires may be either of steel or phosphor-bronze, and before being finally soldered are placed under considerable tension.

The current flows through the instrument thus:—entering, say, by the upper wire connecting the fixed supports, it passes to the upper horizontal bar. There it splits into two, one half (supposing the resistances equal) passing to each end of the bar, and, by means of the corresponding fork-wires, passing through the movable coils. From the movable coils each half returns along the lower horizontal bar and together pass out by the lower wire connecting the two main supports. From this the whole current passes first through the one fixed coil and then through the other, and in such a direction as to produce a repulsion between each pair of coils.

In the constructing care is taken that the suspended coils are both made of equal weight, and that when the balance is in equilibrium no torsion is in any of the wires. Small scale-pans are attached to each vertical bar, and a bob for raising or lowering the centre of gravity of the whole is placed on a rod springing at right angles from the middle of one of the horizontal bars.

The current strength is estimated by the weight needed to restore the balance

to equilibrium when disturbed by the passage of the current. A sliding weight may also be used as in a steelyard.

It will be readily seen that, as in all forms of current-weigher, the weights are proportional to the square of the current strength.

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9. *On a Phenomenon in the Electro-chemical Solution of Metals.* *By* Professor S. P. Thompson, *Ph.D.*

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10. *On the Employment of Chromic Acid instead of Nitric Acid in the Bunsen Cell.* *By* J. Wilson Swan.

Since chromic acid has come into the market at a low price experiments have been made with it with a view to find a non-fuming depolariser capable of replacing nitric acid in the Bunsen cell. It is found that the following mixture is very nearly equal to nitric acid in this respect:—

	Parts by Weight
Nitric acid s.g. 142	1
Chromic acid	3
Sulphuric acid	6
Water	5

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11. *A Variable Standard of Self-induction.* *By* Professor J. Perry, *F.R.S.*

An instrument like that hitherto used as a variable standard by Professor Ayrton and the author was used by Professor Hughes and by Lord Rayleigh. It is a fixed coil of wire, inside which a movable coil is placed. The coils are in series with one another. When their planes are parallel there is either a minimum or a maximum coefficient. When the movable coil is rotated so that its plane makes various angles with the plane of the fixed coil, a pointer shows on a scale the coefficient for that particular position. In the specimen hitherto used the range was very small, but in the specimen exhibited the minimum coefficient was only one-sixth of the maximum, and by winding with finer or coarser wire the readings could be increased or reduced to any extent.

As it was unlikely that any other person would take the trouble to have such standards made, the author hoped for hints at its improvement. It was possible to reduce the lowest reading to zero by introducing a condenser of such a capacity K, that if L is the minimum coefficient of self-induction and R is the resistance,

$$L = KR^2$$

according to Mr. Sumptuer's law concerning a shunted condenser. This law only concerns the case of currents which change from one steady value to the other, and the author had worked out a number of numerical examples showing the error introduced by this assumption when the currents were alternating as sine functions of the time. Two unknowns had to be determined if both the *amplitude* and *lag* were to be the same with the condenser as with lessened self-induction, and therefore there ought to be a coil of wire in series with the condenser. He wanted advice as to whether the introduction of the condenser or the use of an independent second variable standard was the better.

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12. *Hot Twisted Strip Voltmeter.* *By* Professor J. Perry, *F.R.S.*

The author described the behaviour of twisted strips subjected to axial pull. A small elongation is accompanied by a great rotation, so that these strips may be employed in measuring instruments such as weighing machines, aneroid barometers, testing machines, &c. For the Ayrton and Perry voltmeter a double-twisted strip of platinum silver with its ends insulated is initially in tension inside a tube or frame two-thirds brass and one-third iron, a pointer at the middle of the strip

being visible above a dial, and capable of a motion of nearly 360°. When a current passes the pointer rotates, because of the heating of the strip. By continuous making and breaking of a large current through the strip during 72 hours all zero and other errors seem to be eliminated. The highest reading of the exhibited instrument was 2½ volts, so that it is particularly useful in accumulator work.

The author gave the law of transformers generally, and found that a small transformer on the base of the instrument converted it into a voltmeter of any range whatsoever, for alternating currents, the readings being independent of the frequency of alternation of the current. The instrument gave accurate readings whether the strip was vertical or horizontal. The author exhibited twisted strips of carbon made by Messrs. Woodhouse & Rawson, which he intends to use for voltmeters of higher range for continuous current work.

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13. *On the Relative Effects of Steady and Alternate Currents on different Conductors.* *By* William Henry Preece, *F.R.S.*

Sir William Thomson, at the Bath meeting of the British Association, startled the electrical world by asserting that alternate currents entered a distance of only about three millimetres into the heart of a thick, round, copper conductor when the frequency was 150. This 'Diffusion Law,' as he called it, is based on the assumption that a current starts at the surface of the conductor and works its way radially inwards. It is dependent on the coefficient of self-induction and on the frequency—that is, on the number of complete alternations of positive and negative currents transmitted per second.

As this law has a most important bearing on the commercial value of systems of distribution dependent on alternate currents, it becomes most desirable to study the question practically. The verification of the law is almost beyond the reach of experiment. It occurred to the author, however, that if conductors of different materials were taken, such as iron, copper, lead, and platinoid, of easily measurable lengths and of convenient sectional areas, and that measurable and variable currents were transmitted through them, both alternate and direct, approximately similar to those used in practice, it would be possible to study the question by observing the changes of temperature in the conductors, and one would at least observe any difference, if such existed, in the total expenditure of energy in the conductors under these different circumstances. Any addition or diminution of energy expended would give some indication of the operation of the law of diffusion, in comparatively small conductors, without, however, determining the actual distribution of current density.

In the preliminary experiments that were made to determine the mode of procedure and the final form of the apparatus, conductors of copper, iron, lead, and platinoid were used, but in the final experiments only iron and copper were employed. Each metal was taken of the same length and of the following forms:—round rod, flat rod, tube, and stranded cable. The various dimensions are given in the tables. The temperature was in all cases determined from the elongation of the conductor.

The observations were taken sometimes with steady currents and sometimes with alternating currents first. Each kind of current, after being switched on, was kept constant until all expansion ceased, after which the current was instantly changed to the reverse kind, and any change of elongation observed. Each experiment lasted from twenty minutes to half an hour. The results are tabulated, and some of the experiments plotted as curves on a diagram. For this latter purpose observations were taken and recorded at every minute. The abscissa is *time* in minutes, and the ordinates elongation in thousandths of an inch.

As regards copper, it is very clear that, whether the current were steady or alternating, the effect of heat generated in the conductors was virtually the same; but of the different forms the tube gave the best results, owing, doubtless, to the increased radiating surface.

The performance of the iron conductor was very decided. Here there is a large increment of heat, due clearly to reversals of circular magnetisation.

Hysteresis evidently plays a most important function, and the conductor in consequence becomes a source of heat, which varies in intensity, not only with the strength of the current, but also with the frequency of the alternations.

The difference of behaviour between iron and copper is very marked in the sounds they emit when transmitting alternate currents. Iron vibrates mechanically, and emits loud, powerful sounds, filling the room with a roar, and increasing in intensity with the frequency. The sound of copper is very slight, and only perceptible when the ear is close to the conductor, even with the maximum current. It is only what one would expect from rapid variations in emissivity under such alternations.

This vibration, so marked in iron, has a very important bearing on the durability of the insulating material; for it is difficult to conceive any material that could stand such molecular disturbances without injury for any length of time.

The general conclusion to be drawn from these experiments is that practically no serious error has been made in the form of conductors so much used for alternating-current systems, and that nothing cheaper or better has been devised than a simple stranded conductor, coated with a suitable insulating coating, and protected outside with lead, or some impervious and strong material.

They do not solve the question of the distribution of current density through the section of the conductor, but they do show that within the range of practice the total flow of energy is the same in copper conductors, whether it be urged by alternate or by steady currents.

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14. *A new Thermometric Scale.*

By George Forbes, *F.R.S.*, *and* William Henry Preece, *F.R.S.*

The recent Electrical Congress at Paris has adopted the *Joule* as the unit of work, and the *Watt* as the unit of power. The following definitions were unanimously accepted. 'The practical unit of work is the *Joule.* It is equal to 107 C.G.S. units of work. It is the energy expended during one second by an ampere in an ohm.

'The practical unit of power is the *Watt.* It is equal to 107 C.G.S. units of power. The Watt is equal to a Joule per second.'

The *Therm* as the unit of heat, which was proposed by the British Association Committee at Bath last year, did not commend itself to the French members. They preferred for the present to retain the term *Calorie*, notwithstanding the confusion from there being two units of that name. It is said there is only one Calorie in the C.G.S. Centigrade system.

But the question arose—Is there any need for either the Therm or the Calorie? Cannot the Joule be made a thermal unit also, for the latter is only a unit of work? The heat generated in T seconds by C amperes flowing through R ohms (or driven by E volts) is $C^2RT = ECT$ Joules. If we take the mechanical equivalent of heat as approximately 42,140,000 ergs, or 4·2 Joules, it means that 4·2 Joules will raise one gramme of pure water at 4° C. one degree.

We have here the true scientific mode of forming a C.G.S. thermometric scale. If we take the fiducial points of freezing and boiling points of pure water at normal pressure on a column of mercury as usual, and divide the distance into 420 divisions, then each division is a true C.G.S. unit of temperature, and will be passed by the expenditure of one Joule per gramme of water. Instead of employing degrees of temperature we can use these units of temperature, and we can replace the angular symbol x° by t or θ. Thus, to raise one gramme of water from freezing point to boiling point requires 420 Joules, or to raise it to boiling temperature from 62 units it requires 358 Joules. There would be no necessity for coefficients, and calculations would be simplified. Degrees Centigrade would be simply converted into these units by multiplying by 4·2, and degrees Fahrenheit by deducting 32° and multiplying the remainder by 2·33.

An objection to such a scheme has been raised by Professor Potier of Paris, and it is that the mechanical equivalent of heat has not yet been determined with suffi-

cient accuracy to justify its adoption as final He thinks it wrong by nearly one per cent. The principal measurements are:—

Joule (1878)	4·1624
Hirn	4·2485
Violle	4·2701
Regnault	4·2877
Rowlands	—

This ought to be a reason to re-examine the question, and with our existing knowledge of the ohm and the ampere we ought to be able to derive the Joule with an exactitude that will satisfy the scientific world.

15. *Exhibition of Leyden Jars with Multiple Fracture.* *By* J. T. Bottomley, *F.R.S.*, *and* Sir Archibald Campbell, *Bart.*

16. *On Sparkless Electro-magnets.* *By* Professor S. P. Thompson, *Ph.D.*

17. *On the Correspondence between the Molecular Refraction, Dispersion, and Magnetic Rotation of Carbon Compounds.* *By* Dr. J. H. Gladstone, *F.R.S.*, *and* Dr. W. H. Perkin, *F.R.S.*

The molecular refraction, or refraction equivalent, of chemical compounds has been the subject of many recent investigations. It is fully recognised that 'the molecular refraction of a compound is the sum of the molecular refractions of its constituents.' It is also well known that very fundamental differences of chemical structure, such as change of atomicity, or of the mode of combination of such elements as carbon and oxygen, cause a difference in the refraction value.

The molecular dispersion is the difference between the molecular refraction of a body for two different parts of the spectrum, for instance the solar lines A and H. A series of dispersion values may thus be determined for the elements; and these are analogous to the refraction values, but not strictly proportional to them. It is also found that wherever a difference of chemical structure causes a difference in value in regard to refraction, it does so in regard to dispersion. This difference is generally much larger in proportion to the actual amount.

The molecular magnetic rotation of organic liquids has lately been examined minutely, and this has revealed the fact that a corresponding series of values may be determined for their elements or constituents, and also that the same differences of chemical structure which produce changes of refraction or dispersion produce analogous changes in the power of rotating the polarised ray. This shows another point of connection between an electro-magnetic effect and the velocity of light.

18. *On Kerr's Magneto-optic Phenomenon: its Laws and Application for Measuring purposes.* *By* H. E. J. G. du Bois, *Ph.D.*

The rotation of the plane of polarisation on normal reflection from magnets was studied with a special view to its close relation with their magnetisation. The metals were used in the shape of prolate ellipsoids of revolution, on to which small reflecting planes had been ground in different positions. They were magnetised in a coil and their moments measured by the ordinary magnetometric method. The following are the principal results:—

1°. The rotation is proportional to the normal component of temporary or residual magnetisation.

2°. For the ratio of these quantities the name 'Kerr's Constant' is proposed, in honour of the eminent discoverer of these important phenomena.

3°. The temperature variation of Kerr's Constant, if any, is so small that its sign and value could not be determined; it cannot be more than a few per cent. per 100°.

4°. In the case of nickel the rotation vanishes together with the magnetisation at temperatures above 335°, both to reappear on cooling.

5°. The rotation is known to be negative for iron, nickel, and cobalt; in addition magnetite (Fe_3O_4) was found to exhibit a positive rotation (a piece of polished loadstone shows the effect qualitatively).

6°. For these four substances Kerr's Constant was determined in absolute measure as a function of the wave-length. The dispersion is on the whole anomalous; the curves show maxima or minima, however, without discontinuities.

The first law points to an application of the rotation as a measure of the magnetisation, provided the former be determined with sufficient accuracy. On this principle the absolute curve of magnetisation $\mathfrak{J} =$ funct. ($\mathfrak{H}$) was approximately obtained for a small crystal of magnetite from purely optical observations; $\mathfrak{J}$ was found to tend towards a limiting value not much above 350 C.G.S.; of course magnetic measuring methods are out of question with this material. The behaviour of manganese steel was also investigated in this way.

Lastly, the magnetic curves were optically determined for steel, cobalt and nickel, for magnetising forces between 1,300 and 13,000 C.G.S.; supplementary magnetometric observations with an exceedingly powerful coil were made between 200 and 1,300 C.G.S., the latter range not being hitherto covered by any observations that I know of. The curves show a decided tendency of $\mathfrak{J}$ towards a limit, which of course can never actually be observed, but appears to have values (at 100° C.) of about 1,630, 1,200, 530 C.G.S. respectively, for the steel, cobalt, and nickel employed.

WEDNESDAY, SEPTEMBER 18.

The following Reports and Papers were read:—

1. *Report of the Committee for considering the desirability of introducing a Uniform Nomenclature for the Fundamental Units of Mechanics.*

2. *Stereometry.*
By W. W. Haldane Gee, *B.Sc., and* Arthur Harden, *M.Sc., Ph.D.*

This communication related to the methods used for the determination of the volumes of bodies to which the hydrostatic method is not applicable. The authors have devised a convenient form of the instrument first proposed by Say, and afterwards modified by Leslie, Miller, Kopp, Regnault, Paalzow, Rudorf, and Baumhawer. They have also shown that the following method for ascertaining volumes is very generally applicable, and likely to be of considerable service in physico-chemical researches. The body whose volume is desired is enclosed within a vessel of known volume, and then carbon dioxide (or other dry soluble gas) is passed into it for some time. The gas is then displaced by dry air (or other gas), and the volume of the carbon dioxide driven out is ascertained *gravimetrically* by absorption in bulbs containing caustic potash solution. By first filling the vessel with dry air and then driving it out with carbon dioxide, the volume of the air, and hence that of the body, may also be ascertained *volumetrically*, but with less accuracy. The gravimetric method is especially applicable for accurately ascertaining the density of soluble gases. For this purpose it is far more convenient than the process of direct weighing as used by Regnault.

3. *The Specific Heat of Caoutchouc.*
By W. W. Haldane Gee, *B.Sc., and* Hubert L. Terry, *A.I.C.*

A number of determinations have been made of the specific heat of Para india-rubber which had been masticated, hydraulically compressed, and then cut into

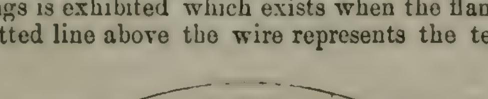
sheets from 0·22 millimetre to 1·40 millimetre thick. The rubber was alternated with sheets of tinfoil and heated for two hours in a steam-jacket at 100° C. A modification of Regnault's method of mixtures was employed to find the specific heat of the hot rubber. Owing to the non-conducting nature of the substance the time of the calorimeter attaining its maximum temperature may be as long as ten minutes; hence it has been necessary to apply special formulæ for the correction due to cooling. Those described by Pfaundler, Pape, and Schuster have been used, and the results calculated in accordance with them. The mean of the best-conducted experiments gives for the Para rubber the number ·481. The investigation is being extended to allied bodies, especially the different forms of vulcanised rubber and gutta-percha.

4. *On the Temporary Thermo-current in Iron.* *By* F. T. Trouton.

If a portion of an iron wire connected up with a galvanometer be heated red-hot and the heated portion be caused to travel along the wire by moving the flame a current is produced. This current is generally greatest in a newly taken wire, but ultimately settles down to a constant thing on repeated heatings.

It is this residual effect which I refer to as a *temporary* thermo-current in order to emphasise the fact that unlike, in the case of other thermo-currents, the consideration of time here enters. At first sight, however, I did not see that this was essential, and I attributed the occurrence of the current to dis-symmetry introduced by the temperature gradient along the wire in front of the moving flame being steeper than that behind, as it evidently must be, owing to the cooling taking place more slowly than the heating. But this can easily be shown not to be the case, for artificially cooling the wire as the flame passes along, so as to make the temperature gradient behind steepest, does not alter the direction of the current. Also if the occurrence of the current depended merely on the temperature gradients it should be possible to obtain a current without moving the flame by arranging that the gradient on each side should be different, but this is not the case. Thus it is seen that the movement along the wire is essential, and that the electromotive force cannot be represented as a function of the temperature gradient alone, but that the *rate* of change of the gradient *with time* is involved.

However, what seems to be the chief interest attaching to this phenomenon is its connection with the phenomenon known as recalescence. Representing the temperature by the ordinates of the curve shown in the figure drawn along the wire the state of things is exhibited which exists when the flame is stationary. If the height of the dotted line above the wire represents the temperature of reca-



lescence we may consider the portion of the wire lying between the points of intersection of the dotted line with the curve as being thermo-electrically a different metal to the rest of the wire, for from the phenomenon of recalescence we know that it is in a different molecular state. Let us call the unaltered wire to right and left 'metal A' and that in the centre 'metal B.' As long as the flame is stationary the two thermo-electric junctions A B, and B A, are at the same temperature, and no current will occur, but this will not be the case when the flame is moved if there is any delay in changing from the 'A' state to the 'B' state, or back, that is to say if the temperature at which the change of state occurs on the rise is higher than that at which it occurs on the fall, as is the case with the melting-point of many organic bodies, especially when they are rapidly heated or cooled, the point of liquefying being higher than the point of solidifying. Thus the junction behind the flame will be at a lower temperature than the junction in front, as is intended to be shown in the figure by the dotted vertical lines; the arrow shows the direction the flame moves; a current will thus ensue, provided 'metal A' is as above stated thermo-electrically different from 'metal B.' The

direction of the current, which is with the motion of the flame, shows that at the hot junction the current is from 'metal B' to 'metal A.'

An apparatus was exhibited which contained a number of circular turns of iron wire which could be continuously heated in four places by the rotation of four gas flames (fed from a central gas pipe and supported by cross pipes pivoted at the centre). These flames were rotated by clockwork attached to the apparatus, the speed of which could be regulated by movable vanes so as to obtain the best effect.

A detailed account of the phenomenon was published by the author in the 'Proceedings of the Royal Dublin Society' (March 1886).

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5. *On Recalescence in Iron. By* Professor Barrett.

When an iron or steel wire is raised to a white heat and allowed to cool, it obeys the ordinary law of cooling until it reaches a point near obscurity. At this point, a temperature of between 700° and 800° C., the temperature suddenly rises, and the wire glows again to a red heat. This phenomenon, known as recalescence, was described by the author at the British Association meeting in Bradford sixteen years ago. During the heating of the wire a reverse action occurs; the temperature momentarily ceases to rise, and even a fall of temperature occurs at the same critical point. This critical temperature is associated with numerous other phenomena which are found to take place in iron and steel. In 1869 Mr. Gore discovered that, on cooling, iron wire momentarily elongated at this temperature; the reverse action, or contraction on heating, was found by the author in 1873, and also that it is at this temperature iron by the action of heat loses its magnetic properties. Further, a curious crepitating sound occurs at this critical temperature, indicating some alteration of structure. Here, too, occurs the curious change in the thermoelectric properties of iron discovered by Professor Tait; and associated with this critical point is the interesting discovery made by Mr. Trouton and described in the preceding paper. Subsequent investigations, both on the Continent and in America, have shown that at this temperature many other important changes in the physical and mechanical properties of steel occur, some of which were described by Professor Roberts-Austen in his recent lecture before the Association. Mr. Tomlinson in London, and Mr. Newall at Cambridge, and recently Dr. Hopkinson, have also given this subject a great deal of attention, and have added much to our knowledge of recalescence and its associated phenomena. The bibliography of the subject and the probable causes of the phenomenon will be contained in the report of a Committee of the British Association, consisting of Professor Fitzgerald, Mr. Newall, Mr. Trouton, and the author, which it is proposed to present to the meeting next year. The present paper is presented more with the object of eliciting discussion on this interesting phenomenon.

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6. *The Cardium, illustrating the true nature of Prime Movers. By* J. Gamgee.

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7. *An Experiment in Colour-blindness.*[1] *By* J. Spiller, *F.C.S.*

Before proceeding to describe his experiment, Mr. Spiller mentioned that he had good proof of his being blessed with the possession of a normal sight, for in the course of a long experience with coal-tar colours, and having frequent occasion to compare observations in regard to slight differences of tint with six colleagues, he had never perceptibly deviated from the consensus of the laboratory staff, and might fairly claim to be reliable on this score. He said that the examination of several colour-blind persons had convinced him of the practical value of a compound tassel of green and grey silk as a preliminary indicator of defective colour vision. He felt desirous of trying an experiment to see whether it was possible by the administration of a small dose of santonine to realise the imperfections of vision which

[1] Printed *in extenso* in the *Photographic News*, September 20, 1889.

seemed common to most colour-blind persons. He took fasting a small dose of santonine—a grain and a half dissolved in a small quantity of alcohol, and diluted with water. In less than five minutes the dose took effect; the white table-cloth appeared of delicate bluish-green colour, and all objects were seen as through spectacles of that tint. He went into the garden to use his spectroscope, and could see all the solar rays in unbroken series with scarcely perceptible variation. There was no actual grey band in the green, but this portion of the spectrum appeared normal and splendidly brilliant. His condition, therefore, was not so abnormal as many of his colour-blind friends. He, however, had to use a word of caution: he only took a quarter dose, but his condition was so serious that he feared the worst consequences, and had to take an emetic of mustard and warm water to give him relief.

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8. *On a new method of Printing Photographic Negatives, employing Living Leaves in place of Sensitive Paper.* *By* Walter Gardiner, *M.A.*

Before coming to the immediate subject of his paper, the author described how prints may be obtained from *Protococci*, or the free swimming swarmspores of many green *Algæ*. It is possible to take advantage of their sensitiveness to light. Into one end of a water-tight box a thin glass plate is securely fitted. The negative to be printed is then placed next the glass, film side nearest. The box is filled with water containing a fairly large quantity of swarmspores, the lid is shut down, and the whole is exposed to diffused light. In the case of a strong and well-developed negative, the swarmspores swim towards the most highly illuminated parts: and there in the greatest numbers: come to rest, and settle down upon the glass, so that after some four or six hours, on pouring out the water and removing the negative, a print in green swarmspores can be obtained. The print is dried, fixed with albumin, stained, and varnished.

The author then dwelt upon the well-known fact that the whole of the animal life upon the globe depends directly or indirectly upon the wonderful synthetic formation of proteid and protoplasm which takes place in the living tissue of plants containing chlorophyll, and stated that whatever is the exact chemical nature of this process, this at least is clear, that the first visible product of assimilatory activity is starch. The presence of this starch can be made manifest by treating a decolorised leaf with a solution of iodine. The formation of starch only takes place under the influence of light. If a plant be placed in the dark over night and then brought out into the light the next morning (the desired leaves being covered by a sharp and well-developed negative) starch is formed where light is transmitted, and in greatest quantity in the brightest areas. Thus a positive in starch is produced which can be developed by suitable treatment with iodine. (A leaf so developed was handed round to the audience.) The author showed that by suitable washing and treatment with some soluble silver salt, silver iodine may be produced and a permanent print obtained.

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9. *A Mode of Photography.* *By* John Hancock.

A mode of photography in which, by the employment of a camera constructed on principles similar to the anatomical formation of the human eyes, it is possible to combine the two inverted pictures of the right and left retinæ into one vertical picture, at a point in the camera coinciding with the point in the brain where the optic nerves from the right and left eye intersect.

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10. *A new form of Self-Registering Actinometer.* *By* Dr. A. Richardson.

See p. 540.

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11. *The Action of Magnetism on Photographic Plates.* *By* Philip Braham, *F.C.S.*

During some investigations I was pursuing concerning magnetism, I surmised that photographic plates could be acted on by that force, but not having sufficient

electrical energy at command to render the result clearly apparent, I waited until an opportunity occurred.

A friend placed at my disposal a battery of sufficient power, and plates of great sensitiveness, with the following results:—

By placing photographic plates between the poles of a powerful electro-magnet and intermitting the current, an action similar to that of light is produced, which on development shows a nebulous appearance in the part directly between the poles and an intense spot at some distance from them.

The magnet used was formed of a ring of soft iron with two solenoids within the diameter; the poles of the solenoids were within fifteen millimetres of each other. The plates first used are known as 'Lumière.'

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12. *Physical and Chemical Constitution of Comets and Meteorites.* *By* PHILIP BRAHAM, *F.C.S.*

The interest which attaches to these periodic and spasmodic visitors, the speculations concerning their place in cosmogony, and their constitution physically and chemically, are questions to which I offer these possible solutions.

In accordance with recorded investigations comets are extremely attenuated masses of gas with very little solid matter.

Meteorites are solid masses of matter with very little gas.

The evidence of the presence of carbon and hydrogen has been invariably found in the spectra of comets.

In meteorites which have fallen the usual meteoric metals have been found, but the occluded gases vary, and might be acquired during their passage through the earth's atmosphere or after their fall.

I venture to intimate that the result of the formation of a solar system is an ellipsoid of magnetic force, the major diameter being in the mean plane of the system with the poles at the extremities of the minor.

The angle at which the plane of the orbit of the comet, and the velocity with which it cuts through this ellipsoid, determines the brilliancy, and the resulting electrical excitements account for the different appearances of these bodies.

The brilliancy of meteorites is due to the heat produced by friction during their passage through the earth's atmosphere.

I have every reason to believe that the gaseous constituents of a comet are aqueous vapour, carbonic acid, and nitrogen in variable proportions.

The above conditions, I conclude, may be the physical and chemical means whereby these phenomena are produced.

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13. *Report of the Committee on certain proposals relative to the Unification of Time and the adoption of a Universal Prime Meridian.*—See Reports, p. 49.

Section B.—CHEMICAL SCIENCE.

President of the Section—Sir Lowthian Bell, Bart., D.C.L., F.R.S., F.C.S., M.Inst.C.E.

THURSDAY, SEPTEMBER 12.

The President delivered the following Address:—

It has occasionally been the practice of former occupants of this chair to devote a considerable portion of the presidential address to the more recent discoveries in chemical science. This branch of learning advances now with such rapid strides and covers so wide a field, that no one who has not made it the business of his life can hope to discharge this duty with even a moderate share of success.

My immediate predecessor, indeed, discouraged any further attempts in this direction on the ground of the impossibility of doing it justice within the limits of a short discourse, and his remarks were consequently directed to the best methods of teaching the science with which Section B is more directly concerned. I propose this morning to add my testimony to the importance of Dr. Tilden's recommendation, by comparing the rate of progress of one of our great national industries as it has been advanced with and without the aid which chemistry is capable of affording. For this purpose I have selected the metallurgy of iron, not only from my greater familiarity with its details, but because, in my judgment, it affords a suitable example for the object I have in view.

It is needless to insist on the disadvantage attending the application of a science to practical work, without a fair knowledge of the principles which regulate its action. At the same time it would be unfair to those who were engaged in the manufacture of iron during the first half of the present century to deny the value of the services which they rendered to their art, without giving much thought to the laws of nature upon which their processes depended. The work so performed sufficed, nevertheless, to place the world in possession of the metal in such abundance and at so low a cost that no engineering works were delayed on account of the high price or absence of the required quality in the produce of our ironworks during the period in question. On the other hand it is not to be denied that since the iron-masters have allied themselves with the chemist they have made more progress in thirty years than their predecessors did in three centuries.

No one unacquainted with the archæology of the iron trade could suppose that the colossal furnaces now pouring forth their streams of molten metal, followed by the rapid action of the Bessemer Converter, were the modern representatives of the iron-making appliances of former days. Out of these last, in a low hearth not larger than a domestic fireplace, often dependent on the wind for their blast, a few pounds of ore were at a considerable cost for labour, fuel, and waste of metal, converted into malleable iron. By means of a modern furnace, in an hour and a half a ten-ton converter can be filled with liquid cast iron, which in twenty minutes may be run into ingots cheaper, stronger, and more malleable than the best wrought iron of our ancestors, or indeed of our own manufacture.

How out of the small fire of the ancient ironworks the German Stück-Ofen was evolved is a matter of conjecture. In both, owing to the conditions under

which the fuel was burnt, carbon dioxide was largely the product of its combustion. The oxidising property of this gas was in each the cause of the waste of metal just spoken of. Probably, and for other reasons than avoiding this loss of iron, attempts were made to increase the dimensions of the Stück-Ofen. If this addition were one of limited extent, the smelter would find, to his cost, that a substance was obtained which no longer possessed the malleable property of that obtained from the lesser furnace. This change would be due to the absorption of carbon, but not in sufficient quantity to constitute that valuable form of the metal known as cast iron. With a material useless for the smith and incapable from its difficult fusibility of being run into moulds, we can understand the delay which took place in the introduction of the blast furnace which about the middle of the sixteenth century gave to cast iron a recognised and valuable position in the arts.

In those days there was no very exact science to appeal to, for two hundred and fifty years after the 'high furnace' of the Germans and French had been set to work, Fourcroy in his 'General System of Chemical Knowledge and its Application to the Phenomena of Science and Art,' arrived at the conclusion that cast metal was erroneously supposed to be a mixture of slag and iron, or a compound of arsenic or manganese and iron. This was written in 1804 in a work of five thousand pages, when he leant to the opinion that Monge and Berthollet were more correct in considering the product of the blast furnace as consisting of iron, oxygen, and carbon.

When the malleable iron-maker had placed in his hands a material containing, as the pig did, more than 90 per cent. of metal, he found it greatly to his advantage to avoid having to deal with all the earthy matter contained in the ores, for it was the presence of silica and alumina which helped to add to the waste incurred in the old hearths. The object sought for in treating ore in the old Catalan fires, as they were called, was one of a reducing or deoxidising character, whereas the reverse of this was required when ore was replaced by pig-iron. In the first case, oxygen had to be removed from the oxide of iron, in the latter oxygen had to be united with the metalloids found in the pig. These were distinctions unknown in the days we are considering, and therefore did not trouble the minds of the ironmasters. In both cases there was a large quantity of oxide of iron present, and when pig-iron was handed over to the Catalan furnace man, it was the oxide of iron so generated which performed the desired duty, and thus this simple mode of procuring malleable iron remained undisturbed for upwards of two hundred years.

The discovery which led to the discontinuance of the low blast furnace as a means of procuring iron in its malleable form was that of puddling made by Cort in 1784. In point of fact Cort's process was merely doing in a reverberatory furnace that which was previously effected by means of compressed air. In an economic point of view, however, the difference is great, and its consequences were of immense importance, for to the puddling furnace we were first indebted for an ample supply of cheap iron by which, in a variety of well-known ways, the interests of the human race have been so largely promoted. As an indication of the indifference of those formerly engaged in industrial pursuits to the scientific aspect of their calling, may be mentioned the fact that puddling had been largely followed for upwards of half a century before it occurred to any one to examine the chemistry of the process.

Down to the beginning of the seventeenth century the only fuel used in the blast furnace, and, indeed, in the manufacture of iron generally, was charcoal. In 1620 Dudley made several attempts to substitute mineral coal in his smelting works for vegetable fuel, which, by the exhaustion of timber, had become very expensive. He failed in this, and in consequence the British iron trade gradually fell until the entire output was not equal to the production of one modern blast furnace. This happened in 1740, when Darby, by treating pit coal in the same fashion as the charcoal burners had done with wood, *i.e.*, by charring it, restored vitality to an expiring industry. It is true that the restoration must have been of a languid character, for in half a century afterwards it is said the weekly produce of a furnace did not exceed fifteen or sixteen tons.

Various changes were introduced into the manufacture of iron in the first

quarter of the present century, but these were rather of a mechanical than of a chemical nature. They chiefly owed their origin to the lessons taught by the chemist Black to James Watt, who profited by them in the application of steam as a motive power. This brings us to the year 1828, a year which will always be distinguished in the annals of the iron trade, by the discovery of Neilson of the value of heated air in smelting the ores of this metal. I never heard it maintained that this inventor had any pretensions to be considered a man of science. Had it been otherwise, the knowledge of the virtues of the hot blast might have been indefinitely postponed, and this opinion is founded on the fact that for many a long year no satisfactory explanation was given why heat, obtained by burning coal, in the hot air apparatus was capable of saving three or four times its weight in the fuel consumed in the furnace itself. I propose, with your permission, to consider this subject with more attention than I shall devote to other portions of this address, and I am led to do this, not only because it is one of some scientific interest, but because its study seems to afford a solution to some questions in respect to which great differences of opinion prevailed among those whose daily work led them to pay much attention to their details. These questions have all a reference to the quantity of fuel consumed in smelting the ore, as this may be affected by the temperature of the blast and the dimensions of the furnaces employed for this purpose.

As is well understood, the heat excited in an iron furnace may be classified under three heads:—

First, that derived from the combustion of the coke at the point where the blast enters the furnace, the ultimate product being carbonic oxide.

Second, the conversion of a portion of this carbonic oxide into carbon dioxide.

Third, the heat carried into the furnace by the blast.

For the better illustration of the relations which the heat derived from these sources bear to one another, a table (No. I) has been prepared in which the quantities of each are given in centigrade calories, and reckoned upon 20 units of iron to correspond with English weights. The information upon which the calculations are based is derived from actual observation gathered from furnaces of different sizes and fed with air at different temperatures.

A second table contains statements showing the manner in which the heat so generated is appropriated in the various divisions of the duty the furnaces had to perform, and for facility of comparison, alongside the quantities of heat so required, their equivalents in the coke used have been added.

In the table No. II. the appropriation of the heat is separated into *Constants* and *Variables*. The first consists of items where the quantity of heat required in making a particular quality of iron is only liable to alterations of trifling amount. On the other hand the variables exhibit in A and B differences so considerable that work which in the furnace blown with cold air absorbed 73,388 calories per 20 cwts. of pig-iron was done with 58,645 calories by merely raising the blast to 485°.

TABLE I.

—	A	B	C	D
Height of furnace in feet	48	48	80	80
Calories—per unit of coke burnt to CO .	2,078	2,028	2,018	2,045
„ from portion of this CO burnt to CO_2	560	1,059	1,636	1,463
Total calories from coke	2,638	3,087	3,654	3,508
Calories in blast	—	508	534	732
Total heat per unit of coke	2,638	3,595	4,188	4,240
Temperature of blast C	0°	485°	485°	695°
Cwts. blast per ton of metal	228	128	103	94
„ escaping gases per ton of metal . .	285	170	138	126
„ slag per ton of metal	34	31	29	28

TABLE II.—*Showing the appropriation of Heat and its equivalent in cwts. of Coke per ton Iron.*

Appropriation of Heat per 20 of Pig Iron	A—Blast 0° C.		B—Blast 485° C.		C—Blast 485° C.		D—Blast 695° C.	
	Calories	Cwts. Coke	Calories	Cwts. Coke	Calories	Cwts. Coke	Calories	Cwts. Coke
CONSTANTS:—								
Reduction of Fe_2O_3 in ore	33,108	12·550	33,108	9·209	33,108	7·905	33,108	7·808
Reduction of metalloids in pig	4,174	1·582	4,174	1·161	4,174	·996	4,174	·984
Dissociation of CO($2CO = C + CO_2$	1,440	·546	1,440	·400	1,440	·344	1,440	·340
Fusion of pig-iron	6,600	2·501	6,600	1·836	6,600	1·576	6,600	1·557
Constant calories per 20 of pig	45,322	—	45,322	—	45,322	—	45,322	—
Coke consumed per 20 of pig . Cwts.	—	17·179	—	12·606	—	10·821	—	10·689
VARIABLES:—								
Evaporation of water in coke	630	·239	411	·114	312	·074	298	·070
Decomposition of water in blast	5,420	2·055	3,348	·931	2,720	·649	2,408	·568
Expulsion of CO_2 in limestone	6,660	2·526	5,920	1·647	5,054	1·207	4,070	·961
Reduction of CO_2 in limestone to CO	6,912	2·620	6,144	1·709	5,248	1·254	4,099	·962
Fusion of slag	18,590	7·045	17,325	4·819	16,720	3·993	15,565	3·673
Carried off in escaping gases	29,482	11·178	18,486	5·144	11,043	2·636	8,906	2·101
Heat in tuyère water at hot-blast furnaces, loss from walls, &c.	5,694	2·158	7,011	1·950	7,057	1·686	9,389	2·216
Variables for 20 of pig	73,388	—	58,645	—	48,154	—	44,735	—
Variables for coke for 20 of pig . Cwts.	—	27·821	—	16·314	—	11·499	—	10·551
SUM OF CONSTANTS AND VARIABLES:—								
Calories for 20 of pig-iron	118,710	—	103,967	--	93,476	—	90,057	—
Cwts. of coke for 20 of pig-iron	—	45·	—	28·92	—	22·32	—	21·24

The cause of this great variation in the amount of heat required for a given weight of pig iron, produced under different circumstances as to temperature of blast and size of furnace, depends on changes in the actual amount of work to be performed. How this variation arises will be best seen in the description of the four examples set forth in the two tables.

Beginning with A, which is a furnace 48 feet in height, blown with cold air and consuming 45 cwts. of coke and 18 cwts. of limestone per ton of metal, the volume of gas produced may be taken at 14,460 cubic yards at ordinary temperatures and pressures. At the temperature at which it escapes we may assume the volume per ton of iron to be about 36,000 cubic yards, passing out of the furnace at the rate of 675 cubic feet per minute.

In comparing the consumption of coal formerly burnt in the hot-air stoves with the saving of coke in the furnace, account must be taken of the different conditions of the combustion. In Table I., owing to the small quantity of carbon dioxide formed, the heat evolved is only 2,638 calories per unit of coke, whereas each unit of the coal consumed in heating the air afforded three times this quantity of heat. Doubtless there was a great loss in the operation of heating the air, for it would not appear that much above one-fourth of the theoretical quantity of heat capable of being generated by the coal reached the furnace through the tuyères.

We have now to consider the nature of the change which is effected in a furnace where, for every 2,638 calories generated by the combustion of the coke, 508 calories are carried in by the blast. It will be readily understood that, with the velocity at which the gases are passing out of the cold-blast furnace, they have but little time to impart their heat to the incoming solids, or to have the carbonic oxide they contain converted into carbon dioxide. The withdrawal of so much coke, and its place taken by heat contained in the blast, means that the 14,460 cubic yards of escaping gases are reduced to about 12,120 cubic yards. The effect of this is not only to alter the speed at which the gases are passing through the materials, but to alter the relation in point of quantity which the ironstone present in the furnace bears to the coke, so that in point of fact a larger space is occupied by the ore than was before, and a lesser one by the fuel. We have thus the carbonic oxide passing more slowly over the oxide of iron at the same time that there is a greater quantity of the oxide exposed to the influence of the reducing gas. To illustrate how this operates, a table has been prepared showing how each 1,000 cubic feet of furnace space is occupied in the four cases we are considering:—

—		A	B	C	D
		48 ft. cold blast	48 ft. hot blast	80 ft. hot blast	80 ft. hot blast
Coke	cubic feet	736	686	590	590
Limestone	„	63	75	86	77
Ironstone	„	201	239	324	333
		1,000	1,000	1,000	1,000

The immediate effect of the introduction of the hot blast is to alter the spaces filled by the three minerals from those given in Column A to coke 686, limestone 75, and ore 239 cubic feet. This is followed by a twofold advantage. Volume for volume, ore and limestone possess double the heat-intercepting power of coke, and there is 19 per cent. more ore ready to oxidise the carbonic oxide passing over it at a reduced speed of 16 per cent. than there was when using cold air. The increased efficiency of the coke, due to a more perfect cooling of the gases and higher oxidation of the carbonic oxide, permits its further suppression until the relative spaces filled by the materials are those shown under Column B. These advantages would not of themselves suffice to save 16 cwts. of coke or thereabouts out of 45 cwts., but the reduction in the coke consumed is followed by a diminution in the quantity of air used and in the weight of gases and slag produced. A reference to

the appropriation of heat classified under the head of Variables will show in consequence diminution from 73,338 to 54,643 calories.

It may be asked whether this prolonged exposure of the ore to the reducing gases could not be secured by driving the furnace at a slower speed. There is, however, a point which may be regarded as one of equilibrium, at which the quantity of cold materials charged at the top just suffices to reduce the temperature of the escaping gases, as far as is possible consistent with the dimensions of the furnace. If the volume of blast entering at the tuyères is lowered one-half it would mean that the materials would be exposed for twice the time to the hot gases that they were previous to the alteration in the rate of driving. The elevation in the temperature of the coke would enable its carbon to act on the carbon dioxide, so that there would ensue as great a loss under the second head of heat evolution in Table I. as there is gained by a more perfect interception of the heat contained in the gases.

There is, however, another way of securing this prolonged exposure of the ore to the action of the reducing gas without incurring the inconvenience just referred to, viz. by increasing the dimensions of the furnace blown with cold air. When this was done by raising the height from 48 to 71 feet it was found that the duty performed by the coke, apart from the heat contained in the blast, was just about the same as that in the hot-blast furnace.

With regard to the position of equilibrium above referred to, it is worthy of remark that, while this was reached when a furnace of 48 feet ran 100 tons per week when driven with cold air, it was not arrived at in one of similar dimensions using heated air until the make was increased to about 220 tons.

When we proceed to examine the composition and weight of the gases given off by a 48-feet furnace blown with air at 485° C. it will be found that about 20 per cent. of the carbon as dioxide has disappeared, due no doubt to the still excessive temperature of the upper zone and too rapid a current of the reducing agent. An obvious way to remedy this evil would be by an addition to the capacity of the furnaces. This was done by raising them to a height of 80 feet, with a cubical space three or four times greater than those of 48 feet. In such a furnace almost the full theoretical quantity of carbon as dioxide has been obtained, but, while the larger furnace held three or four times as much ore, &c., as the smaller one, the production was only about double that of the lesser. On referring to Table II. it will be seen that a further economy of 6·6 cwts. of coke has been effected in Furnace C as compared with B, due solely to an enlargement of space, for the temperature of the blast was exactly the same in both. This improvement, it will also be perceived, is due to an extension of those causes which acted so beneficially when hot air was applied to B.

If 6·6 cwts. of carbon or thereabouts is the full quantity per ton of iron which can be found in the gases as dioxide, and if, in a furnace working under the conditions of C, it requires 22·32 of coke to furnish this carbon and that in the carbonic oxide, it is clear we cannot withdraw any coke without disturbing the position of equilibrium supposed to have been established in the case of the furnace in question. Suppose that into such a furnace the blast, instead of 485°, is admitted at 695° as happened under Column D. The additional heat, 732 calories, instead of 534 as in C, will make itself felt throughout the entire height of the furnace, including of course the upper zone. Immediately this happens some of the carbon dioxide generated by the reduction of the ore attacks the coke and escapes as carbonic oxide. If Table I. is examined it will be seen that almost the whole of the additional heat carried into the furnace D, as compared with C, has been absorbed by the disappearance of carbon dioxide, so that the net power of the coke unit in both cases is practically the same. Nevertheless it will be remarked that there is still a small saving of coke due to a reduced amount of blast, escaping gases, &c.

From what has preceded it has been concluded that a furnace of 80 feet affords sufficient opportunity for the gases being as fully saturated with oxygen as the nature of the process of deoxidising the ore will permit. The sensible heat in the escaping gases, however, still represents a considerable loss, reduced as it has been from 29,482 to 11,043 calories.

According to estimate it was believed that the reduction of oxide of iron ought to be attended by an increase of temperature—in other words, the conversion of carbonic oxide into carbonic dioxide produced more heat than that absorbed by splitting up oxide of iron into its constituent parts. The estimated difference not being a large one, an experiment was made by substituting in the furnace inert substances having about the same specific heat as the ore. The results confirmed the correctness of the calculation—the temperature of the escaping gases fell, and rose to their normal point when the use of ore was recommenced. A more expensive experiment was subsequently made in the same direction by building, at Ferryhill, a pair of furnaces having a height of 103 feet, without any substantial benefit being derived from the large additional expenditure incurred.

It was Scheerer, I think, who first divided the blast furnace into zones. The first division, beginning at the top and extending 12 feet downwards, was designated the preheating zone; the following 18 feet downwards was distinguished as the reducing zone; the next eight feet the carburising zone, followed by four feet which constituted the zone of fusion. The lowest of all having a depth of about six feet, was named the zone of combustion. The author of this mapping out, as it were, of the interior of the furnace does not wish to be understood as confining its various functions within the respective spaces assigned to them; on the contrary, he admits the existence of considerable variations of position. My own observations, however, have led me to conclusions varying considerably from those adopted by Scheerer.

The fundamental cause of these differences seems to depend on the temperature considered as being required for a commencement of the reduction of the ore. By Scheerer the reducing zone is considered to require a temperature of 1,000° to 1,200° C. This change undoubtedly is not the same with all kinds of ores, but my experiments were conducted when using almost every variety of the mineral. According to the trials made a mixture of one volume of carbon dioxide and two volumes of carbonic oxide at a temperature of 410° removed 10 per cent. only of the oxygen in Cleveland ore, and 37·8 per cent. from an artificially prepared oxide. The composition of the gases at the different depths, however, indicates in an unmistakable manner the nature of the action which is going on at any particular point. A table has been prepared from actual analyses of the gases which gives the quantity of oxygen present for every 1,000 parts of metal produced; and to this is added the weight of carbon they contained. The results vary, but the general inference to be drawn from the observations made on furnaces of 80 feet is, that by the time the minerals have passed through a space of eight feet of the depth they have to travel, all the oxygen susceptible of removal from the ore in the upper region is found in the gases, the remainder being retained until it reaches the zone of fusion. The same is the order of action in a somewhat modified form which was found to prevail in the case of furnaces 48 feet in height.

On casting the eye along the lines of figures a somewhat remarkable circumstance is apparent, viz., that the quantity of oxygen per 1,000 of pig iron gradually decreases as the gases ascend, until they approach the upper region, when it commences to increase. This had been the subject of observation for many years without any complete explanation being given of its cause. Dr. Percy, among others, bestowed some attention to the circumstance without arriving at any opinion satisfactory to himself. It is a little extraordinary that, so far as I have seen, no notice has ever been taken of the fact that the carbon in the gases followed the same law. While engaged in investigating the action of furnace gases on the ore a peculiarity was observed previously unknown to me, viz., that large quantities of carbon were deposited by the dissociation of the reducing gas, the action being $2\,CO = CO_2 + C$. Experimentally I ascertained that spongy iron, as well as oxide of iron, was capable of producing the change, and that 30 per cent. of carbon dioxide, mixed with the carbonic oxide, arrested the reaction, the temperature at the time being 420°. Dr. C. A. Wright, who subsequently became chief chemist of our laboratory, was asked to continue the examination. The conclusion arrived at was the impossibility of effecting the complete reduction of Fe_2O_3, or of any oxide,

TABLE III.—*Showing the quantity of Oxygen and Carbon in gases per 1,000 parts of Pig Iron produced. The eight feet immediately below charging plates is occupied by charging apparatus.*

Distance below top of Minerals	0 ft.		8½ ft.		18 ft.		31 ft.		44¼ ft.		57 ft.		62½ ft.		68 ft.	
	O.	C.	O.	C.	O.	C.	O.	C.	O.	C.	O.	C.	O.	C.	O.	C.
No. 1. Oxygen . .	1,843	—	1,250	—	1,235	—	1,234	—	1,236	—	1,207	—	1,137	—	1,348	—
Carbon . .	—	1,101	—	864	—	816	—	871	—	904	—	899	—	890	—	967
No. 2. Oxygen . .	1,843	—	—	—	1,410	—	1,482	—	1,190	—	1,207	—	1,255	—	1,366	—
Carbon . .	—	1,104	—	—	—	914	—	1,046	—	894	—	887	—	—	—	927
No. 3. Oxygen . .	1,670	—	1,309	—	1,206	—	1,312	—	1,256	—	1,253	—	1,253	—	1,378	—
Carbon . .	—	1,048	—	926	—	907	—	918	—	946	—	931	—	939	—	1,013
No. 4. Oxygen . .	1,670	—	1,271	—	1,224	—	1,300	—	—	—	1,261	—	1,285	—	1,387	—
Carbon . .	—	1,048	—	897	—	898	—	917	—	—	—	926	—	977	—	1,021

NOTE.—Nos. 3 and 4 were using partially calcined limestone, hence the deficiency of O. and C. until the lower depths are reached.

TABLE IV.—*Showing what may be regarded as a typical instance of the absence of Carbon Dioxide in the gases taken from a furnace of 80 feet. Measurements taken from the highest level of the minerals,* i.e., *eight feet below charging plates.*

Depth below charge	Escape pipe	3½ ft.	9¾ ft.	16 ft.	22½ ft.	28¾ ft.	35 ft.	41¾ ft.	66 ft.
Carbonic Acid .	16·07	11·71	10·03	8·17	6·12	—	—	·72	3·01
Carbonic Oxide	27·34	29·71	31·39	31·40	32·79	35·27	36·00	36·02	39·47
Hydrogen. .	·11	·10	·07	·14	·28	·10	·11	·08	·14
Nitrogen . .	56·48	58·48	58·51	60·29	60·81	64·63	63·89	63·18	57·38
Total . .	100·	100·	100·	100·	100·	100·	100·	100·	100·

by CO. On the contrary, when metallic iron known to contain no oxygen was exposed to a current of this gas, carbon was deposited and oxygen absorbed. It would seem, therefore, that this absorption of oxygen by the iron and precipitation of carbon suffice to explain the disappearance of these two elements from the gases, and that they remain in this condition until the fusion of the iron, in contact with intensely heated carbon, liberates the oxygen as well as that portion of the carbon which is not absorbed by the metal in order to produce pig-iron.

So far, then, as the analyses given in Table III. enable us to judge, instead of the upper two-thirds of a furnace being required for the purposes of reduction, no material change is effected after passing through 18 feet in a modern furnace of 80 feet in height. After this the composition of the gases, and, therefore, of the minerals, remains pretty steady until the vicinity of the tuyères is reached, with the consequences already referred to.

Of the excess of oxygen at the zone of combustion it is highly probable that a portion is due to the reduction of P_2O_5, SiO_2, SO, and CaO. In the case of Cleveland iron I have estimated this at 54 parts per 1,000 of pig-iron produced, but the average total oxygen, beyond that furnished by the blast in the first two instances given, was 130 parts. At this rate there must have been 76 parts of oxygen liberated from the oxide of iron, which is equal to 19 per cent. of that originally combined with the iron in the ore.

It may be appropriate here to refer to what may be taken as a typical expression of the working of a blast furnace in respect to the presence of carbon dioxide. An analysis of the gases is therefore inserted in Table IV., drawn from an 80-feet furnace at various levels, with the simple remark that it is improbable that carbon dioxide can exist for any length of time when exposed to incandescent coke at the temperature which prevails at the depths mentioned in the last two columns.

Something like forty years ago the escaping gases from the blast furnaces, rich as they were in carbonic oxide, were permitted to burn wastefully on the surface of the minerals charged at the throat. This meant a loss of about 54 per cent. of the heating power of the coke. For reasons already given it was of course impossible to utilise much of this heat in the actual smelting of the ore, because of the necessity of preserving a large excess of carbonic oxide in the gases. This, however, constituted no reason why, apart from the furnace work itself, this vast quantity of gaseous fuel should not have been utilised, as it no doubt would earlier have been, had the ironmakers known, as they now do, its full value. To-day all the blast and other engines are driven and the air is heated at our blast furnaces by fuel formerly wasted, and this without any labour for stoking being required. In Great Britain alone the annual saving from this course is fully equal to four million tons of coal.

In connection with the other volatile products which accompany the iron smelters' work I will only mention ammonia. Some qualities of coal admit of being used in the raw state. In this case, as in distilling coal for illuminating purposes, ammonia is generated and may be collected. Instead, however, of the ammoniacal vapour being all contained in the hydrocarbons as in gas-making, it is diluted in addition with most of the fixed carbon as oxides and all the nitrogen of the atmospheric air used in its combustion. Nevertheless, Messrs. Bairds, of the Gartsherrie works, and others, are manufacturing large quantities of ammonia sulphate from the ammonia so obtained. A similar object is achieved by attaching the necessary condensers to the apparatus for coking coal. The process of distillation is then carried on in hermetically closed ovens heated by the combustion of the gases evolved. These, before reaching the fire-place where they are burnt, are deprived of their ammoniacal vapours by passing through condensers provided for the purpose. Previous, however, to this being done, the waste heat from the coking process had been applied for generating steam, so that at certain collieries in the county of Durham all the mechanical power is obtained without any coal being specially burnt for this purpose.

Before speaking of the next and last great improvements in connection with my subject, I should like to say a few words, and a few words only, respecting steel, a well-known and most valuable compound of iron and carbon. Let me first observe

that it seems improbable that this substance was not earlier known to the ancients, as was at one time supposed. The facility with which the metal combines with carbon renders it very unlikely that acieration would not occasionally take place when iron itself was the object of the manufacturer. Certain it is that Agricola, who wrote in 1556, describes in Latin a mode, apparently as well known as that of making iron itself, of making *Acie*. The engraving in his 'De re metallica' shows bars of malleable iron placed upright in a charcoal fire resembling that of a Catalan hearth. These, after an exposure of several hours to the incandescent charcoal and hot carbonic oxide, were found changed to steel and employed as such.

After the invention of the blast furnace pig-iron was placed in a similar hearth to the Catalan, and while in a melted state a blast of air was directed upon the molten metal, until just as much carbon remained with the iron as constituted steel. This mode of procedure continued to be practised long within my own recollection, and may, for what I know, still be followed in some districts. The subject of steel-making occupied the attention of Hassenfratz, of Réaumur, and others, but practically the only process followed until 1865 was the well-known one of cementation.

Since the days of Fourcroy it had been ascertained that, in addition to the iron, carbon was an essential ingredient in cast metal, but invariably accompanied by more or less silicon, and whenever the minerals contained sulphur or phosphorus these metalloids were also present. The nature of the actions employed for ridding the product of the blast furnace of these substances so as to render it malleable had also been carefully examined and explained by the light of scientific investigation. The manufacturer had, it is true, learnt by experience and observation how to produce an article of excellence without much knowledge of the science of his art. Among other things he ascertained that to obtain a ton of wrought iron he required the heat of an equal weight of coal in the puddling furnace; but he did not know, nor did even men of science, I think, ever dream, that the oxidation of the metalloids in the pig-iron, and that of a small portion of the metal itself, would afford heat enough to enable the workman to dispense with the use of all coal in the process of conversion. When, therefore, the iron trade was informed of this in a paper read before the British Association in 1856, entitled 'A mode of making iron without the use of fuel,' its author, Henry Bessemer, was set down by the iron trade as a deluded enthusiast. At that period I doubt whether ten pounds of wrought iron had ever been seen in a state of fusion at one time. Bessemer in his description, however, spoke of melting tons of it with no more heat than that afforded by the rapid oxidation of about 5 or 6 per cent. of the weight of the pig-iron used. Not only therefore was the subject one of economic but also of high scientific interest. Nevertheless, a mere statement of the title of the paper was all the notice bestowed by our predecessors in their 'Transactions' on a discovery which has revolutionised the art of making iron. It is quite true that for some time it appeared as if the scientific aspect of the question were to constitute its only recommendation, for the malleable iron made in a Bessemer converter proved unmanageable when hot, and destitute of strength when cold. Finally it was ascertained that phosphorus was the source of the evil, and, further, that while carbon and silicon could be almost entirely removed from the molten metal, this third metalloid remained unaffected by the treatment. The extent to which the hurtful influence of phosphorus makes itself felt in the wrought iron obtained by the Bessemer process is somewhat remarkable, because while two- to three-tenths per cent. is often present in puddled bars of fair quality, probably no consumer would accept Bessemer steel when it contains half of this amount. The first success was obtained in Sweden, where by using pig-iron containing a mere trace of the objectionable substance a product was obtained which was satisfactory. For many years the beneficial effect produced by manganese on steel had been well known, and it occurred to R. F. Mushet, son of David Mushet, one of, if not the earliest scientific metallurgists in the United Kingdom, to try its influence in the converter on iron made from the hematite iron of the West of England, which contained from ·05 to ·1 per cent. of phosphorus. This addition, apparently by its removing occluded or combined

oxygen in the molten iron, afforded the necessary relief, and the operation being one of extreme simplicity enables steel or wrought iron to be produced at a greatly reduced cost. To such an extent has this been carried, that ore is brought by sea over a distance of 1,000 miles to Middlesbrough, and from it steel rails are made more cheaply than a greatly inferior article of iron can be produced from the abundant and economically wrought bed of ironstone found within a couple of miles of that town. As an example of the facility of conversion may be adduced the fact that the molten metal is brought direct from the blast furnace, turned into steel or ingot iron as the case may be, and the heat evolved by the operation is sufficient to enable the product in many cases, without further use of fuel, to be taken direct to the mill and rolled into a finished bar.

We have just seen that ·1 per cent., or thereabouts, of phosphorus renders steel or ingot iron valueless; in like manner very insignificant variations in the quantities of carbon or silicon materially affect their quality. Now the blow, as it is termed, in a Bessemer converter may be accomplished in from twelve to fifteen minutes. It is clear therefore that the opportunity of ascertaining the precise quality of the steel is one of very short duration. It is, I think, not disputed that a product can be obtained by this process possessed of very high, if indeed not of the highest, excellence, but it is also pretended that the quality is not sufficiently uniform for certain purposes. The ordinary reverberatory furnace is incapable of affording the necessary temperature for melting steel or wrought iron, but by employing the fuel in a gaseous state, and by heating the air and gas before they are brought together, as is done in the valuable furnace suggested by the Messrs. Siemens, the heat is so intensified that wrought iron in it is rapidly fused. Steel is now largely made in such furnaces, either by mixing wrought and cast iron, as proposed by M. Pierre Martin, or by means of cast iron alone, when the carbon is removed by the addition of iron ore and some limestone, in which case, by the agency of the ore, the metalloids are oxidised and removed from the bath of iron. Some hours being required for this, sufficient opportunity is afforded for ascertaining the progress of the operation.

The cause of the iron in the Siemens furnace as well as in the Bessemer converter retaining its associated phosphorus began in time to attract the attention of chemists. In each case the expulsion of the metalloids is effected by oxidation. The carbon is gasified, and the silicium on being acidified is absorbed and forms a slag containing usually 45 to 50 per cent. of silicic acid. In the presence of such an excess of this substance, any phosphoric acid, if formed, could not be absorbed by the slag. It was the late M. Grüner, of Paris, who, in 1867, first pointed out this fact, and he it was who first recommended the use of lime in order to render the slag basic instead of acid. Further, in order to avoid the presence of silica, he recommended at the same time, that the converter should be lined with lime instead of with fireclay.

The same subject engaged my own attention, when guided by the fact, that as oxide of iron in puddling was capable of acidifying and removing a large quantity of the phosphorus as iron phosphate, it might be possible to make this removal more complete by some modification in the temperature of the furnace. This was found to be practicable without reducing the carbon below the point necessary for the easy fusion of the metal. The result of these experiments was communicated to the Iron and Steel Institute in March, 1877, when it was shown that pig-iron containing 1·75 per cent. of P could in a few minutes have this reduced to ·2 per cent. This process is now being used in the United States for freeing cast iron from most of its associated phosphorus.

The rapid destruction of the ordinary Bessemer converter led Mr. G. I. Snelus to consider the practicability of using a lime lining, and on experimenting with this on a working scale he confirmed the opinions previously enunciated by Grüner by observing that the presence of lime had removed a considerable quantity of the phosphorus. The principles involved in these discoveries constitute the foundation of the very important basic process of Messrs. Thomas and Gilchrist, which consists in adding lime to the molten steel in a converter constructed on the principle described by Mr. Snelus. Considerable difficulty had,

however, been experienced by this metallurgist in the attachment of the lime lining to the walls of the converter. This important question was solved by Mr. Edw. Riley by exposing dolomite to a very high temperature in order to prevent further shrinking, and then grinding it and mixing the powder with coal tar. This formed a species of cement which is applied to the sides and bottom of the converter in the form of bricks or as cement. Doubtless, simple as the idea is, it has greatly contributed to the success of the basic process.[1]

The acidification and subsequent transference to the slag of the phosphorus by the basic treatment has led to its application to agriculture. For this purpose the slag is ground to a fine powder and sprinkled over the land without any further preparation. By this operation an indispensable element of animal life is derived from the remains of living creatures which, ages ago, found a grave in the ferruginous mud destined to become the great Cleveland bed of ironstone.

Before closing this portion of my official duty, I cannot refrain from tendering to chemists an assurance of the great advantage the manufacturers of iron feel they have derived from the lessons taught them by chemical science. I am the more anxious to do this because we, among others, have been reminded that we are losing the supremacy among industrial nations which we once enjoyed for want of that knowledge of chemistry which is more assiduously cultivated abroad than it is in our own country. I am not prepared to deny that the opportunities for acquiring a scientific education are less generally spread here than is the case in France, Germany, or Belgium; but for this the nation, and not the iron trade in particular, is responsible. It must also be admitted that as manufacturers we no longer stand so far above other lands as we formerly did. In this result any differences of education are in no way concerned, for if I were to classify the nationalities of the various inventions enumerated in the course of my remarks the fears of those who are alarmed at the appearance of a Belgian girder or a German steam-engine on our shores would, I think, be allayed. Perhaps I may be allowed to offer a very few words on the technical side of this important question of education. Much I shall not be able to say, because I have not yet been able to learn the precise position which the subject occupies in the minds of its most earnest advocates. If it means, as is sometimes alleged, a system by which, along with scientific instruction, manual dexterity in the use of tools or a practical knowledge of various manufacturing processes has to be acquired, I confess I am not sanguine as to the results. Certain I am that if foreign workmen are more skilful in their trades, which, as a rule, I doubt, and which in the iron trade I deny, this superiority is not due to scientific training in the manner proposed, for in this they possess, so far as I have seen, no advantage over our own workmen. My objection to the whole system is the impossibility of anything approaching a general application being practicable. I have not a word to say against the rudiments of science being taught wherever this is possible. The knowledge so obtained may often give the future workman a more intelligent interest in his employment than he at present possesses, but I think they who expect much good to attend such a thin veneer of chemistry or physics do not take sufficient account of the extent of the knowledge already possessed by more highly educated men who are now directing the great workshops of the world. It is by extending and enlarging this that substantial aid has to be afforded to industry and science, and not by teaching a mere smattering in our primary or any other schools. In the case of young people who from necessity must leave the schoolroom at an early age, my own leaning is towards the present system, with the addition of drawing and some natural science. By these certain important lessons are taught, which, if not followed under the discipline of the schoolmaster, run some risk of being entirely neglected. After this, probably, the playground will be found more useful and much more popular with schoolboys than trying to learn a trade by means of tools which, before he has to use them in earnest, may be thrown into the scrap heap.

As a national question the attention of the Government, Imperial or municipal, ought to be directed to the importance of establishing in all great manufac-

[1] *Vide* Postscript.

turing centres institutions resembling the Physical College of this city. These should consist of appropriate and even handsome buildings, properly furnished with all the instruments and appliances required for teaching the sciences in their practical bearings on industrial pursuits. In Newcastle, as well as in other places, this has been done on a fairly ample scale, and the advantages the College of Science in this city is capable of affording are offered on such terms that no one can plead expense as a barrier to mental improvement.

Bearing in mind the importance of the subject, and remembering, as my colleagues and myself do, the difficulties we have had to encounter and those we have still before us, I am strongly of opinion that the erection and maintenance of colleges of science should not be left to the accidental liberality of the few, but should be taken in hand by the nation at large.

Postscript.—Since writing what has been here said on the Basic Process, Mr. Gilchrist has stated that Mr. Thomas and himself, at the period of their discovery, were ignorant of the work of Professor Grüner. Were the facts otherwise, to these two gentlemen and to others, including Messrs. Bolckow, Vaughan, & Co., great credit is due for having reduced scientific principles to an established branch of industry.

The following Reports and Papers were read:—

1. *Third Report of the Committee for investigating the Influence of Silicon on the properties of Steel.*—See Reports, p. 267.

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2. *Report of the Committee for considering the best method of establishing International Standards for the Analysis of Iron and Steel.*—See Reports, p. 50.

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3. *On Eikonogen, a new Photographic Developer.* *By* Professor G. D. Liveing, *F.R.S.*

This substance is the sodium salt of amido-β-naphthol-β-sulphonic acid.

This acid, $C_{10}H_5.NH_2.OH.SO_3H$, was first described by Professor Meldola in 1881. It has since been obtained in much larger quantity by Witt, and it is now produced on the manufacturing scale by the Actiengesellschaft für Anilinfabrikation at Berlin.

Of all substances tried as developers, perhaps pyrogallol has held its own the longest, though some prefer ferrous oxalate, and of late hydroquinone has been a good deal used. The chemical action of hydroquinone is very similar to that of pyrogallol, and the fact that the former is para-di-hydroxy-benzene, and pyrogallol is a tri-hydroxybenzene, led Dr. Andresen of Berlin to try the effect of other para-derivatives of benzene which, by oxidation, would easily give quinones or similar substances. Para-di-amido-benzene and para-amido-phenol were found to be well adapted for developing photographs. Subsequently Dr. Andresen turned his attention to the sulphonic acids, and the outcome has been that eikonogen appears to fulfil the requirements of a good developer the best.

Dr. Andresen claims for it:—

1. That while eikonogen reduces the bromide of silver so far as it has been subject to the action of light, the bromide in dry gelatine plates which has not been exposed to light remains unaffected by it.

2. That concentrated solutions of eikonogen (1 : 20 to 1 : 50) produce even with instantaneously exposed plates minutely detailed negatives.

3. The tone of the negatives given by eikonogen is well adapted for printing, and in this respect it excels pyrogallol.

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4. *A Note on the Volatilisation of Lead Oxide and its Action upon Glass at Low Temperatures.*[1] *By* T. W. Hogg.

The author described a few simple experiments which show that oxide of lead will corrode or attack glass, and also volatilise in small quantities at a temperature of scarcely visible redness.

If oxide of lead be used as a pigment to write or mark upon a polished plate of glass, and this is then heated to the above-named temperature for about one hour, upon cooling and brushing off the surplus oxide, there will be found a distinct corrosion or etching upon the surface, due to the oxide having entered into combination with the constituents of the glass; this action will take place even below visible redness, in which case the corroded surface is quite smooth; if the operation be conducted at a decided red heat the appearance is like that of a dry hydrofluoric acid etching.

Very pretty results may be obtained by converting this surface corrosion into sulphide of lead; this is easily done by soaking the plate in a solution of ammonium sulphide; brilliant mirror-like films of sulphide of lead may be obtained under certain conditions.

It has also been found that if a plate of glass be heated to a scarcely visible redness its polish is so extremely sensitive to the slightest trace of lead vapour, that this fact may be made use of to show that lead oxide is slightly volatile also at this temperature. To render this evident it is only necessary to place upon a glass plate or platinum foil some writing, using oxide of lead as a pigment; if a polished plate of glass be placed over this as closely as possible, and prevented from actual contact by suitable means, upon now heating up to the previously mentioned temperature for not less than an hour, a distinct reverse of the design will appear upon the surface of the upper glass; the quantity of lead oxide which will produce this effect is not shown by the most delicate balance.

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5. *On the Molecular Weights of the Metals: an application of Raoult's Method to Alloys.* *By* C. T. Heycock, *M.A.*, *and* F. H. Neville, *M.A.*

The authors have made a number of experiments, using sodium, potassium, and especially tin, as solvents, in order to determine the effect produced on the freezing-point of a metal by alloying other metals with it.

They find that if successive quantities of a metal be dissolved in tin, and the freezing-point observed after each addition, the fall in the temperature of the freezing-point is at first sensibly proportional to the amount of foreign metal added. For strong solutions the effect produced by each addition of metal slowly decreases. It often happens that before any gradual falling off in the effect is noticed, the freezing-point becomes constant, no further addition of metal having any effect. This indicates that the tin is saturated with the other metal. The authors think that they have thus determined the exact solubility in tin of silver, copper, and various other metals, at the temperatures at which the respective alloys solidify. These saturated alloys are probably the only ones which can solidify homogeneously.[2]

They find that the effect produced by equal masses of different metals is inversely as their atomic weight—*i.e.*, that 24 grams magnesium produce the same fall as 108 of silver or 196 of gold.

The fall in the temperature of the freezing-point of the tin when one atomic weight of foreign metal was dissolved in 100 atomic weights of tin was, for most of the metals examined, about 2·6° C.; but aluminium produced about half the fall, or 1·2° C., while antimony caused a rise.

Similar results were got when sodium was used as a solvent, but the corresponding fall was about 4° C.; while a few experiments with potassium as a solvent gave 1·7° C. as the fall for the above concentration.

[1] Published *in extenso* in the *Journal of the Society of Chemical Industry*, October 1889.

[2] These saturated alloys are Guthrie's 'eutectic' alloys.

By applying the theory of osmotic pressure (*see* Van 't Hoff's researches) there can be calculated what fall ought to be produced when one *molecular* weight of a metal is dissolved in a given volume of the solvent—in this case 11,800 grams of tin (for formula, *see* Prof. J. J. Thompson's 'Application of Dynamics to Physics and Chemistry,' § 131). The calculated fall is about 3° C.

The authors infer from this that it is probable that the molecules of the majority of metals when in solution in tin are monatomic, but that aluminium is diatomic.

It may be noted that E. Tamman of Dorpat has, by similar experiments, come to the conclusion that when in solution in mercury the molecules of metals are monatomic, and that Professor Ramsay has, by a different method, arrived at the same result.

The authors find that the metals are apparently independent of each other in their action, as several metals can be dissolved at once in the same mass of tin, and each metal will produce its own effect independently of the others present. Hence we may conclude that Dalton's law of 'partial pressures' holds good in these cases of osmotic pressure.

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6. *The Manufacture of Prussiate of Potash.* *By* J. B. Readman, *D.Sc., F.R.S.E.*

The first portion of this paper referred to the present condition of this manufacture, describing the present process as very wasteful and imperfect, and showed that very little attention has of late years been devoted to improving the process, which has remained stationary for nearly half a century.

A general sketch of the process now employed in manufacturing prussiate was next given. Then followed a brief notice of the history of prussiate since its discovery last century, and of the processes that have been proposed or patented to improve the manufacture, and lastly, full details of a series of experiments made by the author to produce prussiate by the action of ammonia gas upon red-hot wood charcoal which had been previously saturated with carbonate of potash.

FRIDAY, SEPTEMBER 13.

The following Report and Papers were read:—

1. *Second Report of the Committee on the present methods of teaching Chemistry.*—See Reports, p. 228.

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2. *The Manufacture of Aluminium from Cryolite.*[1] *By* Professor P. Phillips Bedson, *D.Sc., F.C.S.*

After referring to the fact that the manufacture of aluminium formed the subject of a paper read before this Section at the last Newcastle meeting, in 1863, the author gave a description of the method of manufacture of this metal from cryolite, which had recently been commenced on the Tyne. The production of aluminium from cryolite by its decomposition with metallic sodium, dependent upon the reaction, represented by the following equation,

$$(NaF)_3AlF_3 + 3Na = Al + 6NaF,$$

was first observed by H. Rose and the late Dr. Percy in 1855, but owing to the difficulties associated with this decomposition it has until recently remained a fact of scientific interest only. Professor Netto has, however, successfully overcome

[1] Published in full in the *Chemical News*, Oct. 25, 1889.

these difficulties, and based upon this decomposition a method of manufacturing aluminium on an industrial scale. The mode of procedure is briefly as follows:—

Cryolite mixed with an equal weight of salt is fused in a reverberatory furnace, the molten charge is run into an iron 'converter,' and into the molten mass the sodium necessary for the decomposition of the cryolite is introduced in small quantities, some 5 lbs. at a time. By a special apparatus the sodium is immediately immersed in the molten bath of cryolite and salt, and in this way loss by volatilisation and by burning of the sodium completely guarded against. After 'dipping,' (as this operation is styled,) the charge with the required quantity of sodium, the greater portion of the slags is poured off, and the remainder containing the aluminium is poured into an iron vessel, in which, after cooling, the mass of aluminium is found collected together in a coherent mass, easily separated from the slag. A pure cryolite worked in this manner gives at once practically pure aluminium. To get rid of the influence of impurities in ordinary cryolite, a method of fractional precipitation is used, the charge of molten cryolite in this case being treated first with a portion only of the sodium required; the slags are then poured off into another vessel and the remainder of the sodium added. The metal produced from this second dipping is practically pure aluminium, whereas that from the first contains the silicon and iron formed from the impurities in the cryolite. For the manufacture of the best brands of aluminium the above operations are conducted in crucibles.

The production of one part by weight of aluminium requires the following amounts of materials:—12 parts of cryolite, 12 of common salt, 20 of coal, and 3 of sodium, and 20 parts by weight of slags are produced, containing about 40 per cent. sodium fluoride, 15 per cent. undecomposed cryolite, 43 per cent. salt, a small amount of alumina, and a little aluminium. The slags by treatment with copper may be utilised for the production of an aluminium bronze, and subsequently the sodium fluoride contained in the slag after removal of the aluminium in this way may be converted into cryolite by treatment with aluminium sulphate, when cryolite is produced as represented by the following equation:

$$12NaF + Al_2(SO_4)_3 = 2(Na_3AlF_6) + 3Na_2SO_4.$$

A portion of the paper dealt with a description of the manufacture of sodium from caustic soda by Professor Netto's process, which consists essentially in allowing a stream of liquid caustic soda to flow over a mass of charcoal, heated in a vertical cast-iron retort. The vapours of sodium and gaseous products are conducted through a condenser and the liquid sodium collected in iron dishes. In this process only a portion of the sodium of the caustic soda is obtained as the metal, some being converted into sodium carbonate, and this, together with the unaltered caustic soda, collects at the bottom of the retort, forming a slag which is used largely by paper-makers in place of pure caustic soda. By operating in this manner the fact that caustic soda is decomposed by carbon at a comparatively low temperature is fully utilised, and consequently the decomposition can be effected in cast-iron retorts, whereas to completely decompose caustic soda by carbon a much higher temperature is required, and vessels of cast-steel or wrought-iron employed, inasmuch as a portion of the caustic soda is converted into sodium carbonate, which dilutes the caustic soda and itself requires a very high temperature for its decomposition.

By this method 1 part of sodium requires the following proportions of materials for its production:—10 parts of caustic soda, 1·2 parts of cast-iron for retorts, 12 parts of coke for heating retorts, and 1·5 parts of charcoal for the reduction of the caustic soda; at the same time 9 parts by weight of slag, consisting of carbonate of soda and caustic soda, are produced.

The author expressed his indebtedness to Professor Netto and to the Alliance Aluminium Company for the manner in which they had so kindly aided him in the preparation of the paper, and for the specimens, diagrams, and photographs used in its illustration.

3. *On Chilian Manganese Ore.*[1]

By JOHN PATTINSON, *F.I.C.*, *and* H. S. PATTINSON, *Ph.D.*

Previous to the adoption of the Weldon manganese-recovery process, nearly the whole of the rich manganese ores imported into this country were used to generate chlorine in the manufacture of bleaching-powder. Their value for this purpose depended upon their yield of oxygen. In 1868, about the time that Weldon discovered his process, about 54,000 tons were imported for generating chlorine. In 1888 only about 7,000 tons were imported for this purpose, this amount being sufficient to make up for the small current loss occurring in the Weldon process, and for some other chemical purposes.

In recent years the manufacture of 'ferro-manganese' for use in steel-making has given rise to a new and large demand for rich manganese ores. For this purpose their value depends upon their percentage of metallic manganese.

Manganese ores are now imported from Spain, Portugal, Hungary, Greece, Canada, New Zealand, and Australia, but by far the greatest quantities come from Caucasia and from Chili. During the year 1888 about 85,000 tons of manganese ore were imported for making ferro-manganese, of which quantity about 25,000 tons came from Chili.

So far as we are aware, no analyses of Chilian manganese ores have as yet been published. The three following will therefore be of interest. They are made from samples taken from cargoes of about 1,000 tons each, and may be regarded as representing the nature of the Chilian ores heretofore imported.

—	I.	II.	III.
	Per cent.	Per cent.	Per cent.
Peroxide of manganese	69·23	55·06	66·03
Protoxide of manganese	11·92	23·05	10·39
Peroxide of iron	1·67	4·71	1·50
Oxide of lead	0·09	0·06	0·05
Oxide of copper	0·15	none	0·14
Oxide of zinc	0·10	none	none
Nickel and cobalt	none	none	none
Alumina	4·21	2·80	1·60
Baryta	none	none	3·58
Lime	1·13	2·33	5·36
Magnesia	0·24	0·56	0·13
Potash	2·86	0·46	0·15
Soda	0·08	0·26	0·11
Silica	4·17	7·30	4·75
Carbonic acid (CO_2)	none	0·18	2·53
Sulphuric acid (SO_3)	0·05 (=0·02 % S)	0·13 (=0·05 % S)	1·57 (=0·63 % S)
Phosphoric acid (P_2O_5)	0·12 (=0·05 % P)	0·14 (=0·06 % P)	0·05 (=0·02 % P)
Arsenic	not determined	0·15	0·04
Combined water	3·90	3·00	1·96
Total	99·92	100·19	99·94
Metallic manganese	53·00	52·66	49·79

The analyses were made on the samples dried at 100°C., at which temperature they lost respectively 2·47 per cent., 1·08 per cent., 0·98 per cent. of hygroscopic moisture.

No. I. comes from the neighbourhood of Santiago; Nos. II. and III. are from the vicinity of Coquimbo and Carrizal, which are now the chief ports of shipment. Nos. I. and II. are very hard, compact, amorphous ores, of a bluish-black colour, and often exhibit a conchoidal fracture; No. III., which contains more peroxide

[1] Printed in full in the *Journal of the Soc. of Chem. Industry* 1889, pp. 876–877.

than the others, is softer and of rather a darker colour, and crystals of calcium carbonate are frequently disseminated through it.

The ore occurs in stratified beds varying in thickness from a few inches to 6 feet, and is found outcropping in the sides of the hills belonging to the range which follows the coast of Chili, known as the 'Cordilleras del la costa.'

A characteristic of Chilian manganese ores is the large percentage of protoxide of manganese they contain. In Caucasian and Spanish ores there is not often more than from 1 to 2 per cent. of protoxide. It is known that manganese dioxide acts the part of a feeble acid, and when precipitated carries down with it as manganites protoxide of manganese, baryta, lime, potash, and other bases with which it was in solution, and it is probable that in these ores the protoxide of manganese, the potash, and portions of the baryta, lime, and other bases shown in the above analyses have been precipitated in combination with the peroxide in the form of manganites.

Baryta is frequently found in other manganese ores. Some Caucasian ore contains as much as 2·04 per cent. Potash also is found in other ores, though not often in such quantity as in No. I. We have, however, met with one specimen, not Chilian, which contained as much as 4·15 per cent. The silica in Chilian ore occurs sometimes as quartz and sometimes as silicate of manganese.

The percentage of phosphorus in Chilian ores is very low—a matter of great importance to the steel-maker. The amount varies to a slight extent in various cargoes, and about 0·1 per cent. has sometimes been found. No. II. contains a small quantity of arsenic, which has been shown by Pattinson and Stead ('Journal of the Iron and Steel Institute,' 1888, Part I.) not to be so deleterious an ingredient of steel as phosphorus.

Practically inexhaustible beds of manganese ores, containing between 30 and 40 per cent. of manganese, with a large percentage of calcium carbonate, have also been discovered in Chili; but as yet only the richer ores, containing about 50 per cent. of manganese, and upwards, can be profitably exported.

Should the means of transport become cheaper in the future, these poorer ores may possibly come into the market.

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4. *On Barium Sulphate in Water-box Deposits from the Durham Coal-mine Waters and in Nottingham Sandstone. By* Professor FRANK CLOWES, *D.Sc.*—See Section C, p. 594.

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5. *The Manufacture of the Alloys of Aluminium in the Electric Furnace. By* J. H. J. DAGGER.

Deville's method, modified in detail, is still the chief of the chemical processes for the production of aluminium, and is dependent upon the cost of metallic sodium.

The greatest value of aluminium is, however, in its alloys, and the successful application of the intense heat of the electric arc to their production on a commercial scale marks a departure in electro-metallurgy of which we cannot overestimate the importance, rendering it possible to produce rich alloys of this metal at half the cost of any other method, and so widening the field of their application to an extent hitherto unknown.

At the works of the Cowles Co., Lockport, N.Y., U.S.A., there are in operation fourteen furnaces, the electricity for which is generated by three dynamos, capable of supplying a current of 3,000 to 3,200 ampères, and E.M.F. of 55 to 60 volts.

These furnaces can produce 2,500 lbs. of aluminium bronze (10 per cent.), and 1,800 lbs. of ferro-aluminium (10 per cent.), or a total yield of 430 lbs. of contained aluminium per 24 hours.

The English works of the Company at Milton, Staffordshire, contain twelve furnaces with a 500 horse-power dynamo, built by Messrs. Crompton, and said to be the largest machine in England, and probably in the world; it furnishes a current of 5,000 to 6,000 ampères, with an E.M.F. of 50 to 60 volts.

The production of these works is 2,300 lbs. aluminium bronze (10 per cent.), and 1,800 lbs. ferro-aluminium (10 per cent.), per 24 hours, or 410 lbs. of contained aluminium.

The furnaces are rectangular in form, and are of firebrick; into each end is built a cast-iron tube, through which the carbon electrodes enter the furnace; each electrode consists of a bundle of nine carbons, each $2\frac{1}{4}$ inches diameter, attached to a head of cast iron for a ferro-aluminium furnace, and of cast copper for aluminium bronze or alloys containing copper. This head is secured to copper rods, or 'leads,' which can be readily connected with or disconnected from the flexible cables supplying the current.

Each cable is secured to slides travelling on an omnibus bar of copper overhead, and so can be brought into position opposite the furnaces to be used. The electrodes are arranged so that it is possible, by means of a handle and screw, to advance or withdraw them from each other in the furnace.

The first furnaces were lined with charcoal, but it was found that the intense heat converted it into graphite, which, being a conductor, not only meant loss of power, but the destruction of the furnace walls. This difficulty has been overcome by soaking the charcoal in lime-water and carefully drying before use; each particle of charcoal is thus coated with an insulating shell of lime.

Lining the furnace is the first operation; the bottom of the trough is covered with a layer of prepared charcoal, the electrodes are arranged in the furnace, and a 'former,' a sheet-iron box without top or bottom, each end being arched to fit over the electrodes, is inserted; charcoal is then rammed into the space between it and the firebrick walls. This done, the charge of ore, mixed with coarse charcoal and the metal to be alloyed with the aluminium, in form of turnings or granules, is placed inside the iron box, after which this is carefully withdrawn; the space between the electrodes is bridged by some broken pieces of carbon, the charge is covered with coarse charcoal, and the furnace closed by a heavy cast-iron cover, having a hole in the centre for the escape of gases evolved during the reaction; the cover is luted so as to prevent the entrance of air. The commencing current is about 3,000 ampères, and is gradually increased to 5,000 ampères; a 'run' occupies about $1\frac{1}{2}$ hours. The furnace is allowed to cool; the next, ready charged, is connected with the cables, so that the process is a continuous one, the furnaces being successively charged and connected. The crude metal from the furnace is then re-melted in an ordinary reverberating furnace, a sample being taken from each run and assayed for aluminium. The nature of the reaction that takes place in the electric furnace is not very easy to ascertain; the conditions are unlike those of any other known: the reduction of the aluminium taking place in absence of air and in presence of an enormous excess of carbon, it may be assumed that, at the intense heat of the electric arc, the ore melts and gives up its oxygen to the carbon:—

$$Al_2O_3 + 3C = 3CO + Al_2.$$

In absence of copper, the liberated aluminium absorbs carbon and is converted into a carbide of the metal. The escaping gas which burns at the orifice in the cover is almost entirely composed of CO.

The most valuable of the alloys are those with copper.

Aluminium bronze has great tensile strength. A bar containing 11·0 per cent. aluminium, made by the electric furnace, and tested by the Leeds Forge Co., Lim., gave a tensile strain of 57·27 tons, or 128,400 lbs. to the square inch. One containing 7·5 per cent. aluminium, tested by Professor Unwin, broke under 36·78 tons = 89,743 lbs. to the square inch. In *resistance to compression* this alloy equals the best steel; its *transverse strength*, or rigidity, is about forty times greater than ordinary brass. Its elastic limit is higher than that of mild steel, and it can be worked at a bright red heat as easily as wrought iron.

Its mechanical and physical properties render it useful for every variety of metal work, its high price only having hitherto restricted its use. Its enormous strength and anticorrodible qualities recommend it as valuable above any other alloy for propeller blades, stern and rudder frames, and for hydraulic and engineering work generally.

Above 11 per cent. the alloy becomes brittle, and at 20 per cent. can be powdered readily in a mortar.

The addition of small quantities of aluminium lowers the fusing point of iron, and this is utilised in the 'Mitis' castings. It ensures freedom from blow-holes, increased tensile strength, and high elastic limit. Mr. Keep found that 0·1 per cent. aluminium raised the transverse breaking strength of a ½-inch bar, 12 inches long, from 379 lbs. to 545 lbs., or 44 per cent., and the resistance to impact from 239 lbs. to 254 lbs., or 6 per cent.

The tensile strength of mitis castings may be as high as 27 tons per square inch, with an elongation of 20 per cent.

Another alloy made in the electric furnace is silicon bronze, which, owing to its great strength and tenacity, its resistance to corrosion, combined with high electrical conductivity, is, perhaps, the best metal extant for electric light, telephone, and telegraph wires.

SATURDAY, SEPTEMBER 14.

The Section did not meet.

MONDAY, SEPTEMBER 16.

The following Reports and Papers were read:—

1. *Third Report of the Committee on the Bibliography of Solution.* See Reports, p. 53.

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2. *Third Report of the Committee for investigating the Properties of Solutions.*—See Reports, p. 53.

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3. *Report of the Committee on the Absorption Spectra of Pure Compounds.* See Reports, p. 227.

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4. *Second Report of the Committee for the investigation of the action of Light on the Hydracids of the Halogens in presence of Oxygen.*—See Reports, p. 59.

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5. *Report (Provisional) of the Committee on the Influence of the Silent Discharge of Electricity on Oxygen and other Gases.*—See Reports, p. 54.

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6. *Report of the Committee on the Bibliography of Spectroscopy.* See Reports, p. 344.

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7. *A new Form of Self-registering Actinometer.* *By* ARTHUR RICHARDSON, *Ph.D.*

When chlorine gas is exposed to the influence of sunlight, or other light containing rays of high refrangibility, the volume of the gas increases with the intensity of the light, the change being independent of the direct heating effects due to the light.

This fact is made use of in the present apparatus, a bulb containing chlorine is attached to the beam of a balance, and the expansion of the gas causes sulphuric acid to flow from one position on the beam to another. A movement of the beam is thus brought about; this is registered by means of a pointer attached to the beam, which describes a line on a rotating drum.

The effect of change in volume of the gas, due to variations in temperature, is eliminated by means of a compensating apparatus.

8. *Explosion of a Mixture of Hydrogen, Chlorine, and Oxygen. By* Professor H. B. Dixon, *F.R.S.*

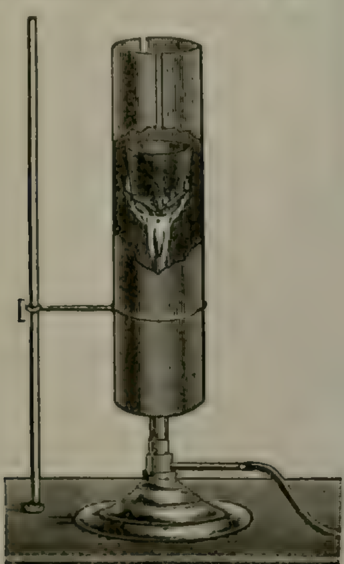
9. *On the Action of Light on Dry Hydrogen and Chlorine. By* Professor H. B. Dixon, *F.R.S., and* J. A. Harker.

10. *On Artists' Colours. By* A. P. Laurie, *M.A., B.Sc.*

This investigation has been undertaken with a view to supplying artists with permanent pigments, at the suggestion of Mr. Holman Hunt. Three lines of inquiry are being pursued, namely, to study the methods used for the preparation of colours in the 15th and 16th centuries as described in the manuscripts of Cennino Cennini and others; 2, to practise the manufacture of colours; 3, to examine modern colours more especially for traces of injurious chemicals. Much valuable information has been obtained, and several colours successfully prepared. It has also been found that different methods are in use in the trade for making the same colour; some samples, for instance, of Prussian blue containing free sulphuric acid, and of vermilion containing potassium sulphide.

11. *Specific and Latent Heat in relation to the combining Heats of the Chemical Elements. By* Dr. W. Newton.

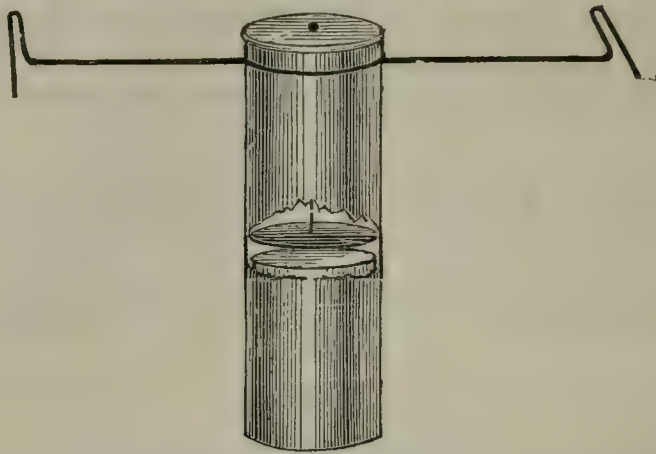
The figures given at present as the heat of combination of the elements only give the exact amount of heat due to chemical action when the elements combining are gases and the compound formed is a gas.



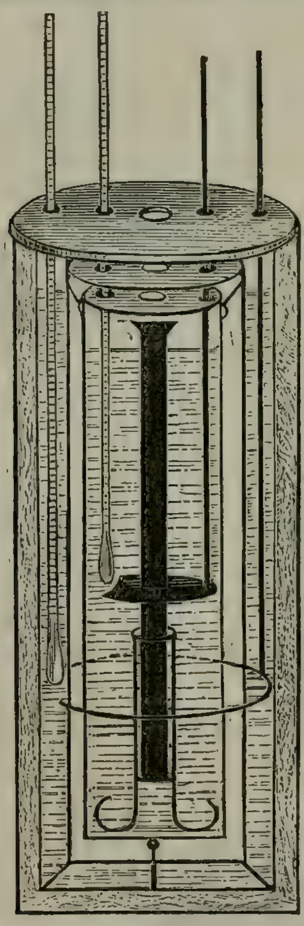
Capsule.

In other cases, where either the elements or their product are solid or liquid, the figures for the heat of combination are made up of chemical heat of combination,

minus the specific and latent heats of fusion and vaporisation of the elements, and plus the specific and latent heats of the compound formed.



The only work on specific and latent heat of substances melting at high temperatures, up to the present, is that of M. Person,[1] who gives the latent heat of



fusion, and specific heats, solid and liquid, of sodium and potassium nitrates, and of some of the elements, such as phosphorus and sulphur.

[1] *Ann. de Chimie*, xxi. p. 333 and xxiv. pp. 129 and 265.

To obtain further data, to find how much of the heat given as combining heat of elements is due to physical change, I have as a first step constructed a special heating apparatus and a calorimeter for determining specific heats, solid and liquid, and latent heat of fusion of high temperatures.

In my apparatus I have used various salts in a large platinum crucible as a bath for obtaining a steady high temperature. The platinum crucible containing the salt was heated inside an iron cylinder.

The weighed quantity of salt whose heat capacity was to be measured, was contained in a platinum capsule formed from two platinum cylinders, each closed at one end. This capsule was dropped into a long platinum tube with arms. As soon as the salt in the salt bath is melted the tube with capsule was inserted in the liquid, and allowed to remain twenty minutes, which time was found sufficient to bring the contents to the temperature of the bath.

The gas under the salt bath was then turned out, and while cooling the salt kept well stirred by moving the platinum tube. The tube is not withdrawn till the salt in salt bath becomes viscous. The tube is then taken out and overset so that the capsule drops into the calorimeter; the temperature of capsule and contents then being the temperature of the solidifying point of the salt bath, which, if NaCl, was 772°; KCl, 734°; $CaCl_2$, 719°.

The calorimeter contained a bell-mouthed long silver tube into which the capsule dropped, and in the lower part of which it fitted moderately closely.

This tube was fitted on a silver wire stand in a long cylindrical silver vessel which contained 500 grammes of water. A long silver wire rising out of the calorimeter was the means of moving a broad silver ring up and down the outside of the tube, and so kept the water well stirred.

The silver vessel was suspended by silk thread in a copper vessel silvered on the inside. This copper vessel was placed in the centre of a second copper vessel of about two centimetres larger diameter. The interspace between these two vessels was filled with water. The second copper vessel was surrounded by a third, the interspace being packed with swansdown.

The thermometers used were two feet long, graduated nine inches from the bottom of the bulb 15° C., and rising to 30°. The degrees were graduated into ·05, and could be read with ease correctly to ·01.

The results obtained are shown in the following table.

Table I.

(The figures for the heat in this table represent calories given by 1 gramme of each salt.)

	I. Total Heat required to melt	II. Heat given out in sinking from 719° to 0°	III. Average Specific Heat 719° to 0°	IV. Landolt and Bornstein's Specific Heat at low temperatures	V. Specific Heat at 719°	VI. Total Specific Heat between 0° and melting point
NaCl	310·27 (Temp. 0°–772°)	163·68	·22765	·21409	·24129	176·47
KCl	231·97 (Temp. 0°–734°)	137·38	·191071	·17295	·209192	140·52

	VII. Latent Heat of Fusion	VIII. Molecular Heat calculated from average Specific Heat between 0° C. and melting point	IX. Molecular Heat calculated from average Specific Heat raised by adding in Latent Heat of Fusion	X. Total Specific Heat between 734° and 772°	XI. Specific Heat Liquid between 734° and 772°
NaCl	133·80	13·37	23·51	—	—
KCl	94·45	14·28	23·88	8·57	·022553

TABLE II.—*Showing the Method of Removing the Anomaly of expressing by a negative quantity the Combining Heat of Salts and Water.*

(The figures in this table for the heat represent calories given by the equivalent weights in grammes of each salt.)

	Equivalent	I. Total Heat required to melt	II. Heat required only to raise the temperature of the Molecules from 0° to melting point, calculated from Specific Heat of gases under constant volume	III. Heat required to overcome the solid cohesion. Difference between figures of Column I. and II.	IV. Heat absorbed in dissolving at 0° in 3,600 grammes of water from Pickering's Experiments	V. Heat of Combination of Salt with Water, the balance from I., II., III., and IV.
NaCl	58·5 grams.	18,151 (Temp. 0°–772°)	4,200	13,950	1,908	12,043
KCl	74·6 grams.	17,529 (Temp. 0°–734°)	3,993	13,536	5,284	8,252

12. *The Composition of Water by Volume.* By Dr. A. SCOTT.

13. *A Spectroscope without a Lens.* By PHILIP BRAHAM, *F.C.S.*

The instrument consists of a taper tube with an adjustable slit 2½ inches long, similar to a parallel ruler at one end and a prism at the other. The length of the tube should allow the slit to be at the distance of distinct vision.

Although the spectroscope is without a lens, the eye acts the part, and produces the image on the retina, which is dispersed by the interposed prism.

Comparison prisms or mirrors can be easily placed before the slit, and the instrument can be easily made by anyone with ordinary constructive ability at a small cost, enabling those whose means are limited to experiment, verify facts, and penetrate the charmed circle of brass and glass, to the popularisation and advancement of science.

TUESDAY, SEPTEMBER 17.

The following Reports and Papers were read:—

1. *Fourth Report of the Committee for investigating Isomeric Naphthalene Derivatives.*—See Reports, p. 172.

2. *Report of the Committee for conferring with the Committee of the American Association with a view of forming a uniform system of recording the results of Water Analysis.*—See Reports, p. 55.

3. *Contributions to the Study of Pure Fermentations.* By Professor PERCY F. FRANKLAND, *Ph.D.*, *B.Sc.*, GRACE C. FRANKLAND, *and* J. J. FOX.

The authors pointed out how very few of the bacterial fermentations hitherto studied have been performed with ferments of undoubted purity, as well as the insufficiency of the description of the morphological characters of the organisms in question. Such scanty descriptions generally render it impossible for other investigators to know whether they are dealing with the same or with different ferments.

The authors have isolated and fully characterised by the modern methods of cultivation an organism, a small bacillus, which sets up fermentation not only in solutions of glucose cane-sugar, milk-sugar, and starch, but also in solutions of mannite, glycerine, and calcium glycerate. The fermentations of mannite and glycerine have alone been so far studied.

In each case the products are essentially the same, viz., principally ethyl, alcohol, and acetic acid, together with smaller quantities of formic acid and a trace of succinic acid. The alcohol was separated by distillation and the quantity determined, whilst the several acids were estimated by conversion into their barium-salts in the case of the acetic and formic acids, whilst the succinic acid was extracted and weighed in the free state.

In the case of the mannite fermentations it was found that the amount of alcohol and acetic acid formed, stood in the proportion of two molecules of alcohol to one molecule of acetic acid, whilst in the glycerine fermentations there were three molecules of alcohol to one of acetic acid.

Of particular interest is the fact that the organism has no fermentative action on dulcite, the isomer of mannite, which thus furnishes a very striking instance of the selective power of micro-organisms between the most closely allied isomeric bodies. The authors were also unable to cause the organism to ferment solutions of either erythrite, ethylene glycol, calcium lactate, tartrate, citrate, or glycollate.

In view of the characteristic products—ethyl, alcohol, and acetic acid—of the fermentations, the authors propose for the organism the name of *Bacillus ethaceticus.* (See also 'Proc. Roy. Soc.' xlvi. 345.)

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4. *The Constitution of the Aromatic Nucleus.*[1]
By S. A. Sworn, *B.A.*, *Assoc.R.C.Sc.I.*

The stability and other properties of the aromatic nucleus are to be explained by assuming that the six atoms are situated at the most symmetrical positions in space—viz., at the angular points of a regular octahedron. Such positions are most consistent with the compactness of the molecular structure. It must not, however, be supposed that the atoms form a rigid structure. By their positions in space we mean merely the mean positions about which they oscillate. That they are in vibration is evident from Hartley's work on the absorption by aromatic compounds of the ultra-violet rays. In order to gain an exact knowledge of the nature of this vibration, it is certainly necessary to know the points about which vibration occurs—that is, the mean positions of the atoms.

Two octahedral formulæ have been proposed—viz. those of Meyer and Thomsen. The former is a modification of Ladenburg's prism symbol. The latter is a development of the diagonal symbol of Claus. They are in a manner complementary to one another, as when superposed they form a complete octahedron. They explain equally well the relationships of the benzene substitution derivatives. No other octahedral symbol will account for these relationships.

Each is characterised by para-linkage, and it may be shown that experimental work necessitates the assumption that there is direct para-linkage in the aromatic nucleus. A symbol, such as that proposed by Armstrong, is, if not meaningless, quite opposed to experimental facts. (See Part I. pp. 5–11.)

Thomsen's symbol must be preferred to that of Meyer, inasmuch as the latter is inadequate for the representation of many experimental facts. (See Part II. pp. 12–15.) A further development of Thomsen's symbol affords a full explanation of the meta- and para-laws of substitution. (See Part III. pp. 15–18.)

Lastly, the acceptance of any symbol which adequately explains the properties of benzene necessitates a modified view of the Van 't Hoff theory. (See pp. 2, 3, and 16.) This theory must be regarded, not as affording any solution of the true positions in space of the atoms, but merely as indicating in a very rough way the general direction in which particular atoms lie.

Isomerism, as explained by the Van 't Hoff theory, is merely an answer to the

[1] Published *in extenso* in the *Phil. Mag.* 1889, Nov. and Dec.

question—On which side of a given line or plane is a certain atom situated? A solution of this question, although important, is by no means a final solution of the far more difficult question of the space relationships of the atoms in a molecule.

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5. *On the Reaction of Benzoquinone with Potassium Cyanide.* *By* S. A. SWORN, *B.A., Assoc.R.C.Sc.I.*

Hydrocyanic acid does not form a compound with benzoquinone. The latter body, however, readily combines with potassium cyanide to form a dark green body, which is obtainable only in aqueous solution. One molecule of the quinone combines with one of the cyanide. Anthraquinone does not form such a compound. Hydrocyanic acid (but no quinone) is given off when the solution is boiled, and quinone is liberated by the addition of silver nitrate solution.

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6. *A new White Lead.* *By* J. B. HANNAY, *F.R.S.E.*

The author gave some details of the various steps which he has taken in the perfecting of his process for making a pure amorphous sulphate of lead from galena, by volatilising and oxidising the sulphide of lead to sulphate in one operation. The problem of condensing the fumes had first to be efficiently solved, because, although some condensors had condensed a large proportion of the fume given off by lead ore, they allowed sufficient to escape to cause a nuisance. A condensor was constructed by which the mixed fume and air were caused to pass horizontally through water, and during the passage the gases were broken up and scrubbed free from the solid fume. Over many months the escape was only 0·2 per cent. of the lead fume in the mixed gases.

The method of making the white consists in volatilising the galena by a blast of air from live coke and fully oxidising the fume in an outer combustion chamber, where the carbonic oxide from the coke is also oxidised to carbonic acid by excess of air. The fumes are then collected, washed, and dried, thus forming a fine powder ready for mixing with oil.

The work is entirely innocuous to the workmen, and after several inspections the works have been exempted from the 'Lead Acts.'

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7. *The half of the Hydrogen atom regarded as a primordial or formative element; and the representation of the Chemical Elements by Physical forms on that basis; with models of the 25 elements from hydrogen to nickel constructed in accordance therewith.* *By* ISAAC ASHE, *M.D., T.C.D.*

If we assume that an element of any given valency is made up of a corresponding number of similar component parts, and if, accordingly, we divide its combining weight by the number representing its valency, we shall find that the fraction ·5 in relation to H = 1 presents itself with very remarkable frequency.

Thus among the monads the combining weights of chlorine and iodine are 35·5 and 126·5 respectively. And among the dyads, dividing their combining weight by 2, we get the following quotients: Be = 4 5; Zn = 32·5; Se = 39·5; Sr = 43·5; Te = 62·5; Ba = 68·5; Yb = 86·5. That is to say, in order to obtain integer quotients we must double the combining weight in each case.

With the triads we obtain in many cases a remainder of 2 when we divide the combining weight by 3, as in B = 11; N = 14; Y = 89; In = 113; Sb = 122; Ta = 182; Tl = 203. This remainder, 2, cannot be correlated with any tripartite system; but if we double the combining weight of the triads, as of the dyads, we get a remainder 1 on dividing by 3. And 1 can be correlated with a tripartite system by making it the central axis thereof.

The tetrads are a very regular group, usually presenting integer quotients when divided by 4; but Zirconium = 90, and Sn = 118, present this same fraction ·5 in their quotients; and Co and Ni, each = 58·5, yield, like the triads, an integer remainder, 1, on doubling their combining weight and then dividing.

These results suggest that the primordial basis is to be found in an element having half the combining weight of hydrogen, as first suggested by Prout, and that any attempt to represent chemical attributes, characters, or potencies by physical forms ought to proceed on this assumption.

Following analogy, the name Dimidium is suggested for this hypothetic element, and, in order to have an integer basis, the combining weights of all the elements are doubled in the present paper.

The relations of attraction and repulsion under the influence of polar forces suggest a linear form for such a primordial element.

Sir W. Thomson's theory of vortex rings as the primordial form of matter, as distinguished from a primordial chemical element, would account for such a linear form; a series of vortex rings, superposed one on the other, would yield a form elongated in one direction while limited in the other two.

If such a series of vortex rings were held in position by forces analogous to gravitation on the one hand, and gaseous repulsion on the other, two points would ultimately be reached in the length of the series of rings where the attractive force of the mass would be exactly balanced by the repulsive force between the last two rings; this would account for the limitation in length of such a series of rings.

Hence we arrive at the conception of a bar-like form of definite length for this primordial element. But the crystalline forms assumed by the known chemical elements suggest that their ultimate atoms are probably solid forms; but, if constructed out of a primordial linear form, they would more probably be skeleton solids than solid throughout. Polar forces, acting with greater intensity at the extremities of linear forms, would also point to skeleton forms for the atoms of the elements. But the atom of hydrogen, consisting of only two such linear forms, would necessarily be a plane form. Under the influence of the forces of repulsion, which result in the separation of the molecules of a gas, *inter se*, these two linear components of hydrogen would probably be held apart at a distance from each other comparable to that separating the molecules of a gas; perhaps equal to the length of the linear element.

A physical distinction is thus suggested between the internal arrangement of the primordial components in the case of a gas, and their arrangement in a solid or liquid. They might probably be thus separated in the case of a gas, and coherent in a solid or a liquid.

The form suggested for the atom of hydrogen is therefore that of two linear components separated by a plane wherein force only operates without the presence of material substance; the molecule of free hydrogen would then be represented by four such linear elements, or bars, placed so as to form the bounding edges of an open cube. Solid hydrogen would be represented by the same four bars placed in lateral contact.

The latent heat of an elementary gas would probably be, in fact, the amount of force required to overcome the mutual attraction of such component bars of the element when thus placed in lateral contact.

In attempting to represent the other elements on this hypothesis, it is necessary to conform to certain data presented by the element as found in Nature, such as, 1, the combining weight—that is to say, the accepted combining weight being stated in relation to hydrogen, twice that number of linear Dimidium elements are to be regarded as contained therein, and so many bars representing this linear element are to be used in the construction of the model. 2. The valency of each element must be exhibited in the model as actually existing in the element in relation to hydrogen. 3. Some representation must be given of the electro-positive and electro-negative conditions as contrasted with each other, and such as to suggest facile combination between elements thus opposed to each other. 4. The possibility of combination between two electro-negative elements, such as N and O, should also be brought out. 5. The crystalline form known to be assumed by any given element ought to come out in the form of the model.

The primary forms into which the primordial linear elements would arrange themselves would probably be those of simple and regular geometrical forms—namely, the equilateral triangle and the square. Secondary forms, skeleton solids,

might be built up out of these; and, finally, forms representing the chemical elements themselves. The conditions are, doubtless, thus made more difficult, but if satisfactory results are nevertheless arrived at, the presumption of their correctness will be greater.

Such secondary forms would be:—

1. Two triangles united along their bases, with a linear element, or bar, connecting their vertices.

2. The open cube, consisting of four squares apposed along pairs of edges, or 16 bars.

3. The closed cube, consisting of six apposed squares, or 24 bars.

4. A solid equilateral triangle, consisting of three squares apposed by pairs of their edges.

5. A system of 10 bars, consisting of two squares apposed by a pair of edges as before, but having their opposite edges separated by single bars.

6. A system of 10 bars, consisting of two triangles apposed by their bases to opposite sides of a square, and joined together at their vertices.

The models suggested as representing elemental forms are exhibited; that for lithium being constructed of two squares apposed by a pair of their linear edges, and separated at their edges opposite to these by the bases of two triangles placed at right angles thereto, the vertices of the triangles coming into apposition again so as to complete a solid figure. 14 bars representing the linear dimidium element are thus employed in constructing the lithium model; the monad valency of the element is represented by the apposed pair of edges of the squares, these being the analogues of the bi-linear form suggested for solid hydrogen.

The salient angle formed by the two squares is suggested as the representation of the electro-positive condition; a corresponding re-entrant angle being found in the models representing electro-negative elements.

The models being constructed for the most part out of equilateral triangles and squares, with single bars occasionally interposed, present angles of 60°, 90°, and 120°, and are very frequently hexagonal in shape. The carbon model is formed by placing two pyramids base to base, each pyramid being formed of four equilateral triangles, in all 24 pieces, its combining number being 12. The crystalline forms, both of the diamond and of graphite, will be seen to correspond with this, the former being made by placing a number of the carbon atoms together by their edges, and the latter by placing them in apposition by their triangular facets.

Silicon is formed by replacing each of these triangles by a group of seven, formed of two triangles united at their bases and separated at their vertices by a single bar component. This will be seen to correspond with both the crystalline forms of silicon; the three-sided terminal pyramids of the silicon crystal being brought out in the model.

Sodium and potassium are so constructed as to correspond with the form adopted for lithium, these being all members of the same series. Similarly, magnesium and calcium are so constructed as to correspond with beryllium; phosphorus and vanadium with nitrogen; sulphur with oxygen; chlorine with fluorine, &c. Sulphur is brought out by replacing the triangles used for oxygen by corresponding groups of seven (No. 1.) This corresponds with both the crystalline forms of sulphur.

Iron, and the group of Tetrad elements analogous with it, are constructed out of a common base form consisting of 88 components, to which two secondary forms in each case, consisting of 20, 22, and 24 components respectively, are added to represent chromium, manganese, and iron respectively. The forms adopted for all these elements correspond with that representing aluminium, so that the replacing of an atom of this latter element by one of any of the former in the alum compounds will be seen to be in accordance with the theoretical forms assigned to these elements.

It seems probable that metals may combine with non-metals by lateral interpenetration, a salient angle of the former corresponding with a re-entrant angle of the latter; but that two non-metals combine by superposition, corresponding angles being applied one to the other. The union of boron with nitrogen at a

high temperature will be seen by reference to the models to be an illustration of this view, taken in connection with that previously expressed of the opening out of elements on passing from the solid to the gaseous condition. It will be seen that boron, if so opened out, could be accurately apposed to nitrogen.

The compounds of oxygen with nitrogen and with chlorine correspond with the forms assigned to these elements. On inspecting the model of chlorine it will be obvious that, though monad in reference to hydrogen, yet, in accordance with the theory of superposition suggested, it can combine with four atoms of oxygen. The addition of hydrogen will then give the oxyacids of chlorine.

It is evident that nitrogen can only combine with two atoms of oxygen, or N_2 with O_3 or O_5 by means of a linking atom of O.

The phenomenon of the expansion of water on passing into the solid state seems explicable by the hexagonal shape suggested for the water molecule; for 6 hexagons apposed by the terminals of their axes so as to allow of free movement would occupy the area of 8 hexagons only, but if locked by their double edges would occupy the area of 9 or $8\frac{1}{3}$ according as they are enclosed in a hexagon or a square. When the six hexagons are thus locked there would be no room for a seventh in the centre, for the water molecule and oxygen atom would be larger than a true hexagon whose sides should be the same length as those of the atom, because of the presence of the central linear components. Hence the seventh, or central, molecule would be shot out when the other six become locked in the process of solidification.

The nascent condition of elementary atoms seems explicable as consisting in the sliding of one atom off another, not in their direct divulsion, each atom thus becoming gradually combined with the replacing atom.

The facility with which the constitution, valencies, and potencies of the different elements may be explained and represented by the adoption of this hypothesis seems to indicate a correspondence between the hypothesis and the actual facts of Nature.

As regards any objection to this hypothesis based on the fractional determinations of Stas, it is to be observed that it is by no means inconceivable that a certain bevelling of the extremities of the linear components might take place in the process of association, the polar forces of attraction between two linear components being probably powerful here, while the forces of aggregation, by which the supposed 'protyle' spheres are held as constituent portions of a single linear component, are presumably weak, as being near the extreme range of their action. Stas's fractions may, in fact, be the statement of such bevelling

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8. *Researches on Sulphites. By* P. J. Hartog, *B.Sc.*

Improved methods for the preparation of sulphites free from sulphates were described. Potassium sulphite, sodium sulphite, and a normal potassium sodium sulphite had been obtained, all crystallising in well-defined hexagonal prisms.

The preparation and thermo-chemistry of a series of double sulphites,

$$2Na^2O, K^2O, 4SO^2, 9H^2O. \quad 2K^2O, Na^2O, 4SO^2, 7H^2O.$$
$$2Na^2O, Am^2O. 4SO^2, 9H^2O.$$
$$2Am^2O, K^2O, 4SO^2, 4, 5H^2O.$$
$$3MgO, Am^2O, 4SO^2, 18H^2O.$$

had been studied, and further research on the subject was in progress.

The consideration of these salts had led the author to the hypothesis that the metasulphites of potassium, sodium, and ammonium contained $4SO^2$. This idea was confirmed by the fact that when sodium and potassium metasulphite are completely neutralised by the addition of ammonia, the heat evolved by the addition of the first half of the amount of base required is sensibly greater than that evolved by the addition of the second half; hence the two reactions must be looked on as distinct. We should therefore double the molecule of the metasulphites, and write the reactions as follows:—

		Cal.
$2Na^2O, 4SO^2 + Am^2O = 2Na^2O, Am^2O, 4SO^2$ (diss, diss, diss)	evolves	+25·05
$2Na^2O, Am^2O, 4SO^2 + Am^2O = 4NaAmSO^3$ (diss, diss, diss)	„	+23·32
$2Na^2O, 4SO^2 + Am^2O = 2K^2O, Am^2O, 4SO^2$ (diss, diss, diss)	„	+26·19
$2K^2O, Am^2O, 4SO^2 + Am^2O = 4KAmSO^3$	„	+23·86

Thermo-chemical data led the author to infer the existence of several isomeric forms of the alkaline double sulphites and metasulphites. The complete solution of the problems dealt with, to which the author hopes to contribute further researches, would be of very great interest.

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9. *Metallic Aluminium as a Chemical Reagent.* *By* J. B. Cohen, *Ph.D.*, *and* R. Ormandy.

Aluminium was found by Cailletet to form an amalgam by connecting the metal with the pole of a battery, and dipped into mercury moistened with acid or into nitrate of mercury. By boiling mercury with the metal no action takes place, but a very rapid surface reaction occurs by bringing the metal into a solution of a mercuric salt. In a few seconds the surface of the metal is covered with an adhering film of metallic mercury, and this amalgamated aluminium forms an electrolytic couple, which rapidly decomposes water at the ordinary temperature. So energetic is the action, that if after amalgamation the metal be carefully washed in water, alcohol, and finally ether, and then dried *in vacuo*, the amalgam on coming in contact with the air becomes so hot that it cannot be held in the fingers, due to decomposition of the atmospheric moisture. When brought into water a rapid and regular disengagement of gas occurs, and at the same time a white flocculent precipitate is formed.

The gas evolved was analysed, and was found to consist of pure hydrogen. The method adopted was to wash it through water, pass it into a eudiometer, and explode with excess of pure oxygen or air according to Bunsen's method; sometimes passing in oxygen and sometimes hydrogen first, using different quantities. The gas was tested against pure hydrogen obtained from zinc and sulphuric acid, washed through alkaline permanganate and from electrolysis of water, and results corresponded fairly. The percentage in the case of the amalgam was in all cases somewhat higher than from the zinc and sulphuric acid.

Estimation of nitrates and nitrites.—The amalgam rapidly decomposes nitrates and nitrites, forming ammonia. The advantage of using this method in water analysis for the estimation of these two compounds is twofold. It is, firstly, much more rapid; and, secondly, it dispenses with the use of caustic soda, which nearly invariably contains nitrites and nitrates, and has led in more than one instance to most erroneous results. The method of carrying out the process is similar to that in which caustic soda is employed, but the time during which the action takes place may be limited to two hours instead of five or six.

The results so far obtained have been very satisfactory.

The reduction of organic bodies.—The amalgam may be used as a powerful reducing agent for organic substances. It reduces nitro-benzene with great violence to aniline. It converts the acid chlorides (aromatic and fatty) into oils having a sweet smell and high boiling-point. These have not been fully investigated.

Section C.—GEOLOGY.

President of the Section—Professor James Geikie, LL.D., F.R.SS. L. & E., F.G.S.

THURSDAY, SEPTEMBER 11.

The President delivered the following Address:—

The President of this Section must often have some difficulty in selecting a subject for his address. It is no longer possible to give an interesting and instructive summary of the work done by the devotees of our science during even one year. So numerous have the students of geological science become, so fertile are the fields they cultivate, so abundant the harvests they reap, that one in my present position may well despair of being able to take stock of the numerous additions to our knowledge which have accumulated within the last twelve months. Neither is there any burning question which at this time your president need feel called upon to discuss. True, there are controversies that are likely to remain unsettled for years to come—there are still not a few matters upon which we must agree to differ—we do not yet see eye to eye in all things geological. But experience has shown that as years advance truth is gradually evolved, and old controversies die out; and so doubtless it will continue to be. The day when controversies shall cease, however, is yet, I hope, far in the future; for should that dull and unhappy time ever arrive, it is quite certain that mineralogists, petrologists, palæontologists, and geologists shall have died out of the world. Following the example of many of my predecessors, I shall confine my remarks to certain questions in which I have been specially interested. And in doing so I shall endeavour to steer clear, as far as I can, of controversial matters. My purpose, then, is to give an outline of some of the results obtained during the last few years by continental workers in the domain of glacial geology.

Those who are not geologists will probably smile when they hear one declare that wielders of the hammer are extremely conservative—that they are slow to accept novel views, and very tenacious of opinions which have once found favour in their eyes. Nevertheless, such is the case; and well for us that it is so. However captivating, however imposing, however strongly supported by evidence a new view may appear to be, we do well to criticise, to sift the evidence, and to call for more facts and experiments, if such are possible, until the proofs become so strong as to approach as near a demonstration as geologists can in most cases expect such proofs to go. The history of our science, and indeed of most sciences, affords abundant illustration of what I say. How many long years were the views of subaerial erosion, as taught by Hutton and Playfair, canvassed and controverted before they became accepted! And even after their general soundness had been established, how often have we heard nominal disciples of these fathers of physical geology refuse to go so far as to admit that the river-valleys of our islands have been excavated by epigene agents! If, as a rule, it takes some time for a novel view to gain acceptance, it is equally true that views which have long been held are only with difficulty discarded. Between the new and the old there is a constant struggle for existence, and if the latter should happen to survive, it is only in a modified form. I have often thought that a history of the evolution of geological

theories would make a very entertaining and instructive work. We should learn from it, amongst other things, that the advance of our science has not always been continuous—now and again, indeed, it has almost seemed as if the movement had been retrograde. Knowledge has not come in like an overwhelming flood—like a broad majestic river—but rather like a gently-flowing tide, now advancing, now retiring, but ever, upon the whole, steadily gaining ground. The history I speak of would also teach us that many of the general views and hypotheses which have been from time to time abandoned as unworkable are hardly deserving of the reproach and ridicule which we in these latter days may be inclined to cast upon them. As the Scotch proverb says: 'It is easy to be wise behindhand.' It could be readily shown that not a few discarded notions and opinions have frequently worked for good, and have rather stimulated than checked inquiry. Such reflections should be encouraging to every investigator, whether he be a defender of the old or an advocate of the new. Time tries all, and each worker may claim a share in the final establishment of the truth.

Perhaps there is no department of geological inquiry that has given rise to more controversy than that which I have selected for the subject of this address. Hardly a single step in advance has been taken without vehement opposition. But the din of contending sides is not so loud now—the dust of the conflict has to some extent cleared away, and the positions which have been lost or maintained, as the case may be, can be readily discerned. The glacialist who can look back over the last twenty-five years of wordy conflict has every reason to be jubilant and hopeful. Many of those who formerly opposed him have come over to his side. It is true he has not had everything his own way. Some extreme views have been abandoned in the struggle; that of a great polar ice-sheet, for example, as conceived of by Agassiz. I am not aware, however, that many serious students of glacial geology ever adopted that view. But it was quite an excusable hypothesis, and has been abundantly suggestive. Had Agassiz lived to see the detailed work of these later days, he would doubtless have modified his notion, and come to accept the view of large continental glaciers which has taken its place.

The results obtained by geologists, who have been studying the peripheral areas of the drift-covered regions of our continent, are such as to satisfy us that the drifts of those regions are not iceberg-droppings, as we used to suppose, but true morainic matter and fluvio-glacial detritus. Geologists have not jumped to this conclusion—they have only accepted it after laborious investigation of the evidence. Since Dr. Otto Torell, in 1875, first stated his belief that the 'diluvium' of North Germany was of glacial origin a great literature on the subject has sprung up, a perusal of which will show that with our German friends glacial geology has passed through much the same succession of phases as with us. At first icebergs are appealed to as explaining everything—next we meet with sundry ingenious attempts at a compromise between floating-ice and a continuous ice-sheet. As observations multiply, however, the element of floating-ice is gradually eliminated, and all the phenomena are explained by means of land-ice and 'schmelz-wasser' alone. It is a remarkable fact that the iceberg hypothesis has always been most strenuously upheld by geologists whose labours have been largely confined to the peripheral areas of drift-covered countries. In the upland and mountainous tracts, on the other hand, that hypothesis has never been able to survive a moderate amount of accurate observation. Even in Switzerland—the land of glaciers—geologists at one time were of opinion that the boulder-clays of the low grounds had a different origin from those which occur in the mountain valleys. Thus it was supposed that at the close of the Pleistocene period the Alps were surrounded by great lakes or gulfs of some inland sea, into which the glaciers of the high valleys flowed and calved their icebergs—these latter scattering erratics and earthy débris over the drowned areas. Sartorius von Waltershausen[1] set forth this view in an elaborate and well-illustrated paper. Unfortunately for his hypothesis, no trace of the supposed great lakes or inland sea has ever been detected—on the con-

[1] 'Untersuchungen über die Klimate der Gegenwart und der Vorwelt,' &c. *Natuurkundige Verhandelingen v. d. Holland. Maatsch. d. Wetensch. te Haarlem*, 1865.

trary, the character of the morainic accumulations, and the symmetrical grouping and radiation of the erratics and perched blocks over the foot-hills and low grounds, show that these last have been invaded and overflowed by the glaciers themselves. Even the most strenuous upholders of the efficacy of icebergs as originators of some boulder-clays admit that the boulder-clay or till, of what we may call the inner or central region of a glaciated tract, is the product of land-ice. Under this category comes the boulder-clay of Norway, Sweden, and Finland, and of the Alpine lands of Central Europe, not to speak of the hilly parts of our own islands.

When we come to study the drifts of the peripheral areas it is not difficult to see why these should be considered to have had a different origin. They present certain features which, although not absent from the glacial deposits of the inner region, are not nearly so characteristic of such upland tracts. I refer especially to the frequent interstratification of boulder-clays with well-bedded deposits of clay, sand, and gravel; and to the fact that these boulder-clays are often less compressed than those of the inner region, and have even occasionally a somewhat silt-like character. Such appearances do seem at first to be readily explained on the assumption that the deposits have been accumulated in water opposite the margin of a continental glacier or ice-sheet—and this was the view which several able investigators in Germany were for some time inclined to adopt.

But when the phenomena came to be studied in greater detail, and over a wider area, this preliminary hypothesis did not prove satisfactory. It was discovered, for example, that 'giants' kettles'[1] were more or less commonly distributed under the glacial deposits, and such 'kettles' could only have originated at the bottom of a glacier. Again, it was found that preglacial accumulations were plentifully developed in certain places below the drift, and were often involved with the latter in a remarkable way. The 'brown-coal-formation' in like manner was violently disturbed and displaced, to such a degree that frequently the boulder-clay is found to underlie it. Similar phenomena were encountered in regions where the drift overlies the Chalk, the latter presenting the appearance of having been smashed and shattered—the fragments having often been dragged some distance, so as to form a kind of friction-breccia underlying the drift, while large masses are often included in the clay itself. All the facts pointed to the conclusion that these disturbances were due to tangential thrusting or crushing, and were not the result of vertical displacements, such as are produced by normal faulting, for the disturbances in question die out from above downwards. Evidence of similar thrusting or crushing is seen in the remarkable faults and contortions that so often characterise the clays and sands that occur in the boulder-clay itself. The only agent that could produce the appearances now briefly referred to is land-ice, and we must therefore agree with German geologists that glacier-ice has overflowed all the drift-covered regions of the peripheral area. No evidence of marine action in the formation of the stony clays is forthcoming—not a trace of any sea-beach has been detected. And yet, if these clays had been laid down in the sea during the retreat of the ice-sheet from Germany, surely such evidence as I have indicated ought to be met with. To the best of my knowledge the only particular facts which have been appealed to, as proofs of marine action, are the appearance of bedded deposits in the boulder-clays, and the occasional occurrence in the clays themselves of a sea-shell. But other organic remains are also met with now and again in similar positions, such as mammalian bones and fresh-water shells. All these, however, have been shown to be derivative in their origin—they are just as much erratics as the stones and boulders with which they are associated. The only phenomena, therefore, that the glacialist has to account for are the bedded deposits which occur so frequently in the boulder-clays of the peripheral regions, and the occasional silty and uncompressed character of the clays themselves.

The intercalated beds are, after all, not hard to explain. If we consider for a moment the geographical distribution of the boulder-clays, and their associated aqueous deposits, we shall find a clue to their origin. Speaking in general terms

[1] These appear to have been first detected by Professor Berendt and Professor E. Geinitz.

the stony clays thicken out as they are followed from the mountainous and high-lying tracts to the low ground. Thus they are of inconsiderable thickness in Norway, the higher parts of Sweden, and in Finland, just as we find is the case in Scotland, Northern England, Wales, and the hilly parts of Ireland. Traced south from the uplands of Scandinavia and Finland, they gradually thicken out as the low grounds are approached. Thus in Southern Sweden they reach a thickness of 43 metres or thereabout, and of 80 metres in the northern parts of Prussia, while over the wide low-lying regions to the south they attain a much greater thickness—reaching in Holstein, Mecklenburg, Pomerania, and West Prussia a depth of 120 to 140 metres, and still greater depths in Hanover, Mark Brandenburg, and Saxony. In those regions, however, a considerable portion of the 'diluvium' consists, as we shall see presently, of water-formed beds.

The geographical distribution of the aqueous deposits which are associated with the stony clays is somewhat similar. They are very sparingly developed in districts where the boulder-clays are thin. Thus they are either wanting, or only occur sporadically in thin irregular beds, in the high grounds of Northern Europe generally. Further south, however, they gradually acquire more importance until in the peripheral regions of the drift-covered tracts they come to equal and eventually to surpass the boulder-clays in prominence. These latter, in fact, at last cease to appear, and the whole bulk of the 'diluvium' along the southern margin of the drift area appears to consist of aqueous accumulations alone.

The explanations of these facts advanced by German geologists are quite in accordance with the views which have long been held by glacialists elsewhere, and have been tersely summed up by Dr. Jentzsch.[1] The northern regions, he says, were the feeding-grounds of the inland ice. In those regions melting was at a minimum, while the grinding action of the ice was most effective. Here, therefore, erosion reached its maximum—ground-moraine or boulder-clay being unable to accumulate to any thickness. Further south melting greatly increased, while ground-moraine at the same time tended to accumulate—the conjoint action of glacier-ice and sub-glacial water resulting in the complex drifts of the peripheral area. In the disposition and appearance of the aqueous deposits of the 'diluvium' we have evidence of an extensive sub-glacial water-circulation—glacier-mills that gave rise to 'giants' kettles'—chains of sub-glacial lakes in which fine clays gathered—streams and rivers that flowed in tunnels under the ice, and whose courses were paved with sand and gravel. Nowhere do German geologists find any evidence of marine action. On the contrary, the dove-tailing and interosculation of boulder-clay with aqueous deposits are explained by the relation of the ice to the surface over which it flowed. Throughout the peripheral area it did not rest so continuously upon the ground as was the case in the inner region of maximum erosion. In many places it was tunnelled by rapid streams and rivers, and here and there it arched over sub-glacial lakes, so that accumulation of ground-moraine proceeded side by side with the formation of aqueous sediments. Much of that ground-moraine is of the usual tough and hard-pressed character, but here and there it is somewhat less coherent and even silt-like. Now a study of the ground-moraines of modern glaciers affords us a reasonable explanation of such differences. Dr. Brückner[2] has shown that in many places the ground-moraine of Alpine glaciers is included in the bottom of the ice itself. The ground-moraine, he says, frequently appears as an ice-stratum abundantly impregnated with silt and rock-fragments—it is like a conglomerate or breccia which has ice for its binding material. When this ground-moraine melts out of the ice—no running water being present—it forms a layer of unstratified silt or clay, with stones scattered irregularly through it. Such being the case in modern glaciers, we can hardly doubt that over the peripheral areas occupied by the old northern ice-sheet boulder-clay must frequently have been accumulated in the same way. Nay, when the ground-moraine melted out and dropped here and there into quietly-flowing water it might even acquire in part a bedded character.

[1] *Jahrb. d. königl. preuss. geologischen Landesanstalt für* 1884, p. 438.

[2] Die Vergletscherung des Salzachgebietes, &c.: *Geographische Abhandlungen, herausgegeben v. A. Penck*, Band I., Heft 1.

The limits reached by the inland ice during its greatest extension are becoming more and more clearly defined, although its southern margin will probably never be so accurately determined as that of the latest epoch of general glaciation. The reasons for this are obvious. When the inland ice flowed south to the Harz and the hills of Saxony it formed no great terminal moraines. Doubtless many erratics and much rock-rubbish were showered upon the surface of the ice from the higher mountains of Scandinavia, but owing to the fanning-out of the ice on its southward march such superficial débris was necessarily spread over a constantly widening area. It may well be doubted, therefore, whether it ever reached the terminal front of the ice-sheet in sufficient bulk to form conspicuous moraines. It seems most probable that the terminal moraines of the great inland ice would consist of low banks of boulder-clay and aqueous materials—the latter, perhaps, strongly predominating, and containing here and there larger and smaller angular erratics which had travelled on the surface of the ice. However that may be, it is certain that the whole region in question has been considerably modified by subsequent denudation, and to a large extent is now concealed under deposits belonging to later stages of the Pleistocene period. The extreme limits reached by the ice are determined rather by the occasional presence of rock-striæ and *roches moutonnées*, of boulder-clay and northern erratics, than by recognisable terminal moraines. The southern limits reached by the old inland ice appear in this way to have been tolerably well ascertained over a considerable portion of Central Europe. Some years ago I published a small sketch-map [1] showing the extent of surface formerly covered by ice. On this map I did not venture to draw the southern margin of the ice-sheet in Belgium further south than Antwerp, where northern erratics were known to occur; but the more recent researches of Belgian geologists show that the ice probably flowed south for some little distance beyond Brussels.[2] Here and there in other parts of the Continent the southern limits reached by the northern drift have also been more accurately determined, but, so far as I know, none of these later observations involves any serious modification of the sketch-map referred to.

I have now said enough, however, to show that the notion of a general ice-sheet having covered so large a part of Europe, which a few years ago was looked upon as a wild dream, has been amply justified by the labours of those who are so assiduously investigating the peripheral areas of the 'great northern drift.' And perhaps I may be allowed to express my own belief that the drifts of Middle and Southern England, which exhibit the same complexity as the 'lower diluvium' of the Continent, will eventually be generally acknowledged to have had a similar origin. I have often thought that whilst politically we are happy in having the sea all round us, geologically we should have gained perhaps by its greater distance. At all events we should have been less ready to invoke its assistance to explain every puzzling appearance presented by our glacial accumulations.

I now pass on to review some of the general results obtained by continental geologists as to the extent of area occupied by inland ice during the last great extension of glacier-ice in Europe. It is well known that this latest ice-sheet did not overflow nearly so wide a region as that underneath which the lowest boulder-clay was accumulated. This is shown not only by the geographical distribution of the youngest boulder-clay, but by the direction of rock-striæ, the trend of erratics, and the position of well-marked moraines. Gerard de Geer has given a summary [3] of the general results obtained by himself and his fellow-workers in Sweden and Norway; and these have been supplemented by the labours of Berendt, Geinitz, Hauchecorne, Keilhack, Klockmann, Schröder, Wahnschaffe, and others in Germany, and by Sederholm in Finland.[4] From them we learn that the end-moraines

[1] *Prehistoric Europe*, 1881.

[2] See a paper by M. E. Delvaux: *Ann. de la Soc. géol. de Belg.*, t. xiii., p. 158.

[3] *Zeitschrift d. deutsch. geolog. Ges.*, Bd. xxxvii., p. 177.

[4] For papers by Berendt and his associates see especially the *Jahrbuch d. k. preuss. geol. Landesanstalt*, and the *Zeitschr. d. deutsch. geol. Ges.* for the past few years; Geinitz: *Forsch. z. d. Landes- u. Volkskunde*, I., 5; *Leopoldina*, xxii., p. 37; *I. Beitrag z. Geologie Mecklenburgs*, 1880, pp. 46, 56. Sederholm: *Fennia*, I., No. 7.

of the ice circle round the southern coasts of Norway, whence they sweep south-east by east across the province of Gottland in Sweden, passing through the lower ends of Lakes Wener and Wetter, while similar moraines mark out for us the terminal front of the inland ice in Finland—at least two parallel frontal moraines passing inland from Hango head on the Gulf of Finland through the southern part of that province to the north of Lake Ladoga. Further north-east than this they have not been traced; but, from some observations by Helmersen, Sederholm thinks it probable that the terminal ice-front extended north-east by the north of Lake Onega to the eastern shores of the White Sea. Between Sweden and Finland lies the basin of the Baltic, which at the period in question was filled with ice, forming a great Baltic glacier, which overflowed the Aland Islands, Gottland, and Öland, and which, fanning out as it passed towards the south-west, invaded, on the south side, the Baltic provinces of Germany, while, on the north, it crossed the southern part of Scania in Sweden and the Danish islands to enter upon Jutland.

The upper boulder-clay of those regions is now recognised as the ground-moraine of this latest ice-sheet. In many places it is separated from the older boulder-clay by interglacial deposits, some of which are marine, while others are of fresh-water and terrestrial origin. During interglacial times the sea that overflowed a considerable portion of North Germany was evidently continuous with the North Sea, as is shown not only by the geographical distribution of the interglacial marine deposits, but by their North Sea fauna. German geologists generally group all the interglacial deposits together, as if they belonged to one and the same interglacial epoch. This perhaps we must look upon as only a provisional arrangement. Certain it is that the fresh-water and terrestrial beds which frequently occur on the same or a lower level, and at no great distance from the marine deposits, cannot in all cases be contemporaneous with the latter. Possibly, however, such discordances may be accounted for by oscillations in the level of the interglacial sea—land and water having alternately prevailed over the same area. Two boulder-clays, as we have seen, have been recognised over a wide region in North Germany. In some places, however, three or more such boulder-clays have been observed overlying one another throughout considerable areas, and these clays are described as being distinctly separate and distinguishable the one from the other.[1] Whether they with their intercalated aqueous deposits indicate great oscillations of one and the same ice-sheet—now advancing, now retreating—or whether the stony clays may not be the ground-moraines of so many different ice-sheets, separated the one from the other by true interglacial conditions, future investigations must be left to decide.

The general conclusions arrived at by those who are at present investigating the glacial accumulations of Northern Europe may be summarised as follows:—

1. Before the invasion of Northern Germany by the inland ice the low grounds bordering on the Baltic were overflowed by a sea which contained a boreal and arctic fauna. These marine conditions are indicated by the presence under the lower boulder-clay of more or less well-bedded fossiliferous deposits. On the same horizon occur also beds of sand, containing fresh-water shells, and now and again mammalian remains, some of which imply cold and others temperate climatic conditions. Obviously all these deposits may pertain to one and the same period, or more properly to different stages of the same period—some dating back to a time when the climate was still temperate, while others clearly indicate the prevalence of cold conditions, and are therefore probably somewhat younger.

2. The next geological horizon in ascending order is that which is marked by the 'Lower Diluvium'—the glacial and fluvio-glacial detritus of the great ice-sheet which flowed south to the foot of the Harz Mountains. The boulder-clay on this horizon now and again contains marine, fresh-water, and terrestrial organic remains, derived undoubtedly from the so-called preglacial beds already referred to. These latter, it would appear, were ploughed up and largely incorporated with the old ground-moraine.

[1] H. Schröder: *Jahrb. d. k. preuss. geol. Landesanstalt für* 1887, p. 360.

3. The interglacial beds which next succeed contain remains of a well-marked temperate fauna and flora, which point to something more than a mere partial or local retreat of the inland ice. The geographical distribution of the beds and the presence in these of such forms as *Elephas antiquus*, *Cervus elephas*, *C. megaceros*, and a flora comparable to that now existing in Northern Germany, justify geologists in concluding that the interglacial epoch was one of long duration, and characterised in Germany by climatic conditions apparently not less temperate than those that now obtain. One of the phases of that interglacial epoch, as we have seen, was the overflowing of the Baltic provinces by the waters of the North Sea.

4. To this well-marked interglacial epoch succeeded another epoch of arctic conditions, when the Scandinavian inland ice once more invaded Germany, ploughing through the interglacial deposits, and working these up in its ground-moraine. So far as I can learn, the prevalent belief among geologists in North Germany is that there was only one interglacial epoch; but, as already stated, doubt has been expressed whether all the facts can be thus accounted for. There must always be great difficulty in the correlation of widely-separated interglacial deposits, and the time does not seem to me to have yet come when we can definitely assert that all those interglacial beds belong to one and the same geological horizon.

I have dwelt upon the recent work of geologists in the peripheral areas of the drift-covered regions of Northern Europe because I think the results obtained are of great interest to glacialists in this country. And for the same reason I wish next to call attention to what has been done of late years in elucidating the glacial geology of the Alpine lands of Central Europe—and more particularly of the low grounds that stretch out from the foot of the mountains. Any observations that tend to throw light upon the history of the complex drifts of our own peripheral areas cannot but be of service. It is quite impossible to do justice in this brief sketch to the labours of the many enthusiastic geologists who within recent years have increased our knowledge of the glaciation of the Alpine lands. At present, however, I am not so much concerned with the proofs of general glaciation as with the evidence that goes to show how the Alpine ground-moraines have been formed, and with the facts which have led certain observers to conclude that the Alps have endured several distinct glaciations within Pleistocene times. Swiss geologists are agreed that the ground-moraines which clothe the bottoms of the great Alpine valleys, and extend outwards sometimes for many miles upon the low grounds beyond are of true glacial origin. Now these ground-moraines are closely similar to the boulder-clays of this country and Northern Europe. Like them, they are frequently tough and hard-pressed, but now and again somewhat looser and less firmly coherent. Frequently also they contain lenticular beds, and more or less thick sheets of aqueous deposits—in some places the stony clays even exhibiting a kind of stratification—and ever and anon such water-assorted materials are commingled with stony clay in the most complex manner. These latter appearances are, however, upon the whole best developed upon the low grounds that sweep out from the base of the Alps. The only question concerning the ground-moraines that has recently given rise to much discussion is the origin of the materials themselves. It is obvious that there are only three possible modes in which those materials could have been introduced to the ground-moraine: either they consist of superficial morainic débris which has found its way down to the bottom of the old glaciers by crevasses; or they may be made up of the rock-rubbish, shingle, gravel, &c., which doubtless strewed the valleys before these were occupied by ice; or, lastly, they may have been derived in chief measure from the underlying rocks themselves by the action of the ice that overflowed them. The investigations of Penck, Blaas, Böhm, and Brückner appear to me to have demonstrated that the ground-moraines are composed mostly of materials which have been detached from the underlying rocks by the erosive action of the glaciers themselves. Their observations show that the regions studied by them in great detail were almost completely buried under ice, so that the accumulation of superficial moraines was for the most part impossible; and they advance a number of facts which prove positively that the ground-moraines were formed and accumulated under ice. I cannot here recapitulate the evidence, but must content myself by a reference to the papers in which

this is fully discussed.[1] These geologists do not deny that some of the material may occasionally have come from above, nor do they doubt that pre-existing masses of rock-rubbish and alluvial accumulations may have been incorporated with the ground-moraines; but the enormous extent of the latter, and the direction of transport and distribution of the erratics which they contain cannot be thus accounted for, while all the facts are readily explained by the action of the ice itself, which used its subglacial débris as tools with which to carry on the work of erosion.

Professor Heim and others have frequently asserted that glaciers have little or no eroding power, since at the lower ends of existing glaciers we find no evidence of such erosion being in operation. But the chief work of a glacier cannot be carried on at its lower end, where motion is reduced to a minimum, and where the ice is perforated by sub-glacial tunnels and arches, underneath which no glacial erosion can possibly take place; and yet it is upon observations made in just such places that the principal arguments against the erosive action of glaciers have been based. If all that we could ever know of glacial action were confined to what we can learn from peering into the grottoes at the terminal fronts of existing glaciers, we should indeed come to the conclusion that glaciers do not erode their rocky beds to any appreciable extent. But as we do not look for the strongest evidence of fluviatile erosion at the mouth of a river, but in its valley- and mountain-tracks, so if we wish to learn what glacier-ice can accomplish we must study in detail some wide region from which the ice has completely disappeared. When this plan has been followed, it has happened that some of the strongest opponents of glacial erosion have been compelled by the force of the evidence to go over to the other camp. Dr. Blaas, for example, has been led by his observations on the glacial formations of the Inn valley to recant his former views, and to become a formidable advocate of the very theory which he formerly opposed. To his work and the memoirs by Penck, Brückner, and Böhm already cited, and especially to the admirable chapter on glacier-erosion by the last-named author, I would refer those who may be anxious to know the last word on this much-debated question.

The evidence of interglacial conditions within the Alpine lands continues to increase. These are represented by alluvial deposits of silt, sand, gravel, conglomerate, breccia, and lignites. Penck, Böhm, and Brückner find evidence of two interglacial epochs, and maintain that there have been three distinct and separate epochs of glaciation in the Alps. No mere temporary retreat and re-advance of the glaciers, according to them, will account for the phenomena presented by the interglacial deposits and associated morainic accumulations. During interglacial times the glaciers disappeared from the lower valleys of the Alps—the climate was temperate, and probably the snow-fields and glaciers approximated in extent to those of the present day. All the evidence conspires to show that an interglacial epoch was of prolonged duration. Dr. Brückner has observed that the moraines of the last glacial epoch rest here and there upon löss, and he confirms Penck's observations in South Bavaria that this remarkable formation never overlies the morainic accumulations of the latest glacial epoch. According to Penck and Brückner, therefore, the löss is of interglacial age. There can be little doubt, however, that löss does not belong to any one particular horizon. Wahnschaffe[2] and others have shown that throughout wide areas in North Germany it is the equivalent in age of the 'Upper Diluvium,' while Schumacher[3] points out that in the Rhine valley it occurs on two separate and distinct horizons. Professor Andreæ has likewise shown[4] that there are an upper and lower löss in Alsace—each characterised by its own special fauna.

There is still considerable difference of opinion as to the mode of formation of

[1] Penck: *Die Vergletscherung der deutschen Alpen.* Blaas: *Zeitsch. d. Ferdinandeums*, 1885. Böhm: *Jahrb. d. k. k. geol. Reichsanstalt*, 1885, Bd. xxxv., Heft 3. Brückner: *Die Vergletscherung d. Salzachgebietes*, &c., 1886.

[2] *Abhandl. z. geol. Specialkarte v. Preussen*, &c., Bd. vii. Heft 1; *Zeitschr. d. deutsch. geol. Gesellsch.*, 1885, p. 904; 1886, p. 367.

[3] *Hygienische Topographie von Strassburg i. E.*, 1885.

[4] *Abhandl. z. geol. Specialkarte v. Elsass-Lothringen*, Bd. vii., Heft 2.

this remarkable accumulation. By many it is considered to be an aqueous deposit; others, following Richthofen, are of opinion that it is a wind-blown accumulation; while some incline to the belief that it is partly the one and partly the other. Nor do the upholders of these various hypotheses agree amongst themselves as to the precise manner in which water or wind has worked to produce the observed results. Thus, amongst the supporters of the aqueous origin of the löss, we find this attributed to the action of heavy rains washing over and re-arranging the material of the boulder-clays.[1] Many, again, have held it probable that löss is simply the finest loam distributed over the low grounds by the flood-waters that escaped from the northern inland ice and the *mers de glace* of the Alpine lands of Central Europe. Another suggestion is that much of the material of the löss may have been derived from the denudation of the boulder-clays by flood-water during the closing stages of the last cold period. It is pointed out that in some regions at least the löss is underlaid by a layer of erratics, which are believed to be the residue of the denuded boulder-clay. We are reminded by Klockmann[2] and Wahnschaffe[3] that the inland ice must have acted as a great dam, and that wide areas in Germany &c. would be flooded, partly by water derived from the melting inland ice, and partly by waters flowing north from the hilly tracts of Middle Germany. In the great basins thus formed there would be a commingling of fine silt-material derived from north and south, which would necessarily come to form a deposit having much the same character throughout.

From what I have myself seen of the löss in various parts of Germany, and from all that I have gathered from reading and in conversation with those who have worked over löss-covered regions, I incline to the opinion that löss is for the most part of aqueous origin. In many cases this can be demonstrated, as by the occurrence of bedding and the intercalation of layers of stones, sand, gravel, &c., in the deposit; again, by the not infrequent appearance of fresh-water shells; but perhaps chiefly by the remarkable uniformity of character which the löss itself displays. It seems to me reasonable also to believe that the flood-waters of glacial times must needs have been highly charged with finely-divided sediment, and that such sediment would be spread over wide regions in the low grounds—in the slack-waters of the great rivers and in the innumerable temporary lakes which occupied, or partly occupied, many of the valleys and depressions of the land. There are different kinds of löss or löss-like deposits, however, and all need not have been formed in the same way. Probably some may have been derived, as Wahnschaffe has suggested, from the denudation of boulder-clay. Possibly, also, some löss may owe its origin to the action of rain upon the stony clays, producing what we in this country would call 'rain-wash.' There are other accumulations, however, which no aqueous theory will satisfactorily explain. Under this category comes much of the so-called *Berglöss*, with its abundant land-shells, and its generally unstratified character. It seems likely that such löss is simply the result of subaerial action, and owes its origin to rain, frost, and wind acting upon the superficial formations, and rearranging their finer-grained constituents. And it is quite possible that the upper portion of much of the löss of the lower grounds may have been reworked in the same way. But I confess I cannot yet find in the facts adduced by German geologists any evidence of a dry-as-dust epoch having obtained in Europe during any stage of the Pleistocene period. The geographical position of our continent seems to me to forbid the possibility of such climatic conditions, while all the positive evidence we have points rather to humidity than dryness as the prevalent feature of Pleistocene climates. It is obvious, however, that after the flood-waters had disappeared from the low grounds of the Continent, subaerial action would come into play over the wide regions covered by glacial and fluvio-glacial deposits. Thus, in the course of time these deposits would become modified,—just as similar accumulations in these islands have been top-dressed, as it were, and to some extent even rearranged. I am strengthened in these views by the conclusions arrived at

[1] Laspeyres: *Erläuterungen z. geol. Specialkarte v. Preussen*, &c., *Blatt Gröbzig, Zörbig, und Petersberg.*

[2] Klockmann: *Jahrb. d. k. preuss. geol. Landesanstalt für* 1883, p. 262.

[3] Wahnschaffe: *Op. cit.* and *Zeitschr. d. deutsch. geol. Ges.* 1886, p. 367.

by M. Falsan, the eminent French glacialist. Covering the plateaux of the Dombs, and widely spread throughout the valleys of the Rhone, the Ain, the Isère, &c., in France, there is a deposit of löss, he says, which has been derived from the washing of the ancient moraines. At the foot of the Alps, where black schists are largely developed, the löss is dark grey; but west of the secondary chain the same deposit is yellowish, and composed almost entirely of silicious materials, with only a very little carbonate of lime. This *limon* or löss, however, is very generally modified towards the top by the chemical action of rain, the yellow löss acquiring a red colour. Sometimes it is crowded with calcareous concretions; at other times it has been deprived of its calcareous element and converted into a kind of pulverulent silica or quartz. This, the true löss, is distinguished from another *lehm*, which Falsan recognises as the product of atmospheric action—formed, in fact, in place from the disintegration and decomposition of the subjacent rocks. Even this lehm has been modified by running water—dispersed or accumulated locally, as the case may be.[1]

All that we know of the löss and its fossils compels us to include this accumulation as a product of the Pleistocene period. It is not of postglacial age—even much of what one may call the 'remodified löss' being of Late Glacial or Pleistocene age. I cannot attempt to give here a summary of what has been learned within recent years as to the fauna of the löss. The researches of Nehring and Liebe have familiarised us with the fact that at some particular stage in the Pleistocene period a fauna like that of the alpine steppe-lands of Western Asia was indigenous to Middle Europe, and the recent investigations of Woldřich have increased our knowledge of this fauna. At what horizon, then, does this steppe-fauna make its appearance? At Thiede Dr. Nehring discovered in so-called löss three successive horizons, each characterised by a special fauna. The lowest of these faunas was decidedly arctic in type; above that came a steppe-fauna, which last was succeeded by a fauna comprising such forms as mammoth, woolly rhinoceros, *Bos*, *Cervus*, horse, hyæna, and lion. Now, if we compare this last fauna with the forms which have been obtained from true postglacial deposits—those deposits, namely, which overlie the younger boulder-clays and flood-accumulations of the latest glacial epoch, we find little in common. The lion, the mammoth, and the rhinoceros are conspicuous by their absence from the postglacial beds of Europe. In place of them we meet with a more or less arctic fauna, and a high-alpine and arctic flora, which, as we all know, eventually gave place to the flora and fauna with which Neolithic man was contemporaneous. As this is the case throughout North-Western and Central Europe, we seem justified in assigning the Thiede beds to the Pleistocene period, and to that interglacial stage which preceded and gradually merged into the last glacial epoch. That the steppe-fauna indicates relatively drier conditions of climate than obtained when perennial snow and ice covered wide areas of the low ground goes without saying; but I am unable to agree with those who maintain that it implies a dry-as-dust climate, like that of some of the steppe-regions of our own day. The remarkable commingling of arctic and steppe-faunas discovered by Woldřich in the Böhmerwald[2] shows, I think, that the jerboas, marmots, and hamster-rats were not incapable of living in the same regions contemporaneously with lemmings, arctic hares, Siberian social voles, &c. But when a cold epoch was passing away the steppe-forms probably gradually replaced their arctic congeners, as these migrated northwards during the continuous amelioration of the climate.

If the student of the Pleistocene faunas has certain advantages in the fact that he has to deal with forms many of which are still living, he labours at the same time under disadvantages which are unknown to his colleagues who are engaged in the study of the life of far older periods. The Pleistocene period was distinguished above all things by its great oscillations of climate—the successive changes being repeated, and producing correlative migrations of floras and faunas. We know that arctic and temperate faunas and floras flourished during interglacial

[1] Falsan: *La Période glaciaire*, p. 81.

[2] Woldřich: *Sitzungsb. d. kais. Akad. d W. math. nat. Cl.*, 1880, p. 7; 1881, p. 177; 1883, p. 978.

times, and a like succession of life-forms followed the final disappearance of glacial conditions. A study of the organic remains met with in any particular deposit will not necessarily, therefore, enable us to assign these to their proper horizon. The geographical position of the deposit, and its relation to Pleistocene accumulations elsewhere must clearly be taken into account. Already, however, much has been done in this direction, and it is probable that ere long we shall be able to arrive at a fair knowledge of the various modifications which the Pleistocene floras and faunas experienced during that protracted period of climatic changes of which I have been speaking. We shall even possibly learn how often the arctic, steppe-, prairie-, and forest-faunas, as they have been defined by Woldřich, replaced each other. Even now some approximation to this better knowledge has been made. Dr. Pohlig,[1] for example, has compared the remains of the Pleistocene faunas obtained at many different places in Europe, and has presented us with a classification which, although confessedly incomplete, yet serves to show the direction in which we must look for further advances in this department of inquiry.

During the last twenty years the evidence of interglacial conditions both in Europe and America has so increased that geologists generally no longer doubt that the Pleistocene period was characterised by great changes of climate. The occurrence at many different localities on the Continent of beds of lignite and fresh-water alluvia, containing remains of Pleistocene mammalia, intercalated between separate and distinct boulder-clays, has left us no alternative. The interglacial beds of the Alpine lands of Central Europe are paralleled by similar deposits in Britain, Scandinavia, Germany, and France. But opinions differ as to the number of glacial and interglacial epochs—many holding that we have evidence of only two cold stages and one general interglacial stage. This, as I have said, is the view entertained by most geologists who are at work on the glacial accumulations of Scandinavia and North Germany. On the other hand, Dr. Penck and others, from a study of the drifts of the German Alpine lands, believe that they have met with evidence of three distinct epochs of glaciation, and two epochs of interglacial conditions. In France, while some observers are of opinion that there have been only two epochs of general glaciation, others, as, for example, M. Tardy, find what they consider to be evidence of several such epochs. Others again, as M. Falsan, do not believe in the existence of any interglacial stages, although they readily admit that there were great advances and retreats of the ice during the Glacial period. M. Falsan, in short, believes in oscillations, but is of opinion that these were not so extensive as others have maintained. It is therefore simply a question of degree, and whether we speak of oscillations or of epochs, we must needs admit the fact that throughout all the glaciated tracts of Europe, fossiliferous deposits occur intercalated among glacial accumulations. The successive advance and retreat of the ice, therefore, was not a local phenomenon, but characterised all the glaciated areas. And the evidence shows that the oscillations referred to were on a gigantic scale.

The relation borne to the glacial accumulations by the old river alluvia which contain relics of palæolithic man early attracted attention. From the fact that these alluvia in some places overlie glacial deposits, the general opinion (still held by some) was that palæolithic man must needs be of postglacial age. But since we have learned that all boulder-clay does not belong to one and the same geological horizon—that, in short, there have been at least two, and probably more, epochs of glaciation—it is obvious that the mere occurrence of glacial deposits underneath palæolithic gravels does not prove these latter to be postglacial. All that we are entitled in such a case to say is simply that the implement-bearing beds are younger than the glacial accumulations upon which they rest. Their horizon must be determined by first ascertaining the relative position in the glacial series of the underlying deposits. Now, it is a remarkable fact that the boulder-clays which underlie such old alluvia belong, without exception, to the earlier

[1] Pohlig: *Sitzungsb. d. Niederrheinischen Gesellschaft zu Bonn*, 1884; *Zeitschr. d. deutsch. geolog. Ges.*, 1887, p. 798. For a very full account of the diluvial European and Northern Asiatic mammalian faunas by Woldřich, see *Mém. de l'Acad. des Sciences de St. Pétersbourg*, VIIe Sér., t. xxxv., 1887.

stages of the Glacial period. This has been proved again and again, not only for this country but for Europe generally. I am sorry to reflect that some twenty years have now elapsed since I was led to suspect that the palæolithic gravels and cave-deposits were not of postglacial but of glacial and interglacial age. In 1871–72 I wrote a series of papers for the 'Geological Magazine' in which were set forth the views I had come to form upon this interesting question. In these papers it was maintained that the alluvia and cave-deposits could not be of postglacial age, but must be assigned to preglacial and interglacial times, and in chief measure to the latter. Evidence was led to show that the latest great development of glacier-ice in Europe took place after the southern pachyderms and palæolithic man had vacated England—that during this last stage of the Glacial period man lived contemporaneously with a northern and alpine fauna in such regions as Southern France—and, lastly, that palæolithic man and the southern mammalia never revisited North-Western Europe after extreme glacial conditions had disappeared. These conclusions were arrived at after a somewhat detailed examination of all the evidence then available—the remarkable distribution of the palæolithic and ossiferous alluvia having, as I have said, particularly impressed me. I coloured a map to show at once the areas covered by the glacial and fluvio-glacial deposits of the last glacial epoch, and the regions in which the implement-bearing and ossiferous alluvia had been met with, when it became apparent that the latter never occurred at the surface within the regions occupied by the former. If ossiferous alluvia did here and there appear within the recently glaciated areas it was always either in caves, or as infra- or interglacial deposits. Since the date of these researches our knowledge of the geographical distribution of Pleistocene deposits has greatly increased, and implements and other relics of palæolithic man have been recorded from many new localities throughout Europe. But none of this fresh evidence contradicts the conclusions I had previously arrived at; on the contrary, it has greatly strengthened my general argument.

Professor Penck was, I think, the first on the Continent to adopt the views referred to. He was among the earliest to recognise the evidence of interglacial conditions in the drift-covered regions of Northern Germany, and it was the reflections which those remarkable interglacial beds were so well calculated to suggest that led him into the same path as myself. Dr. Penck has published a map [1] showing the areas covered by the earlier and later glacial deposits in Northern Europe and the Alpine lands, and indicating at the same time the various localities where palæolithic finds have occurred. And in not a single case do any of the latter appear within the areas covered by the accumulations of the last glacial epoch.

A glance at the papers which have been published in Germany within the last few years will show how greatly students of the Pleistocene ossiferous beds have been influenced by what is now known of the interglacial deposits and their organic remains. Professors Rothpletz [2] and Andreæ,[3] Dr. Pohlig, [4] and others do not now hesitate to correlate with those beds the old ossiferous and implement-bearing alluvia which lie altogether outside of glaciated regions.

The relation of the Pleistocene alluvia of France to the glacial deposits of that and other countries has been especially canvassed. Rothpletz, in the paper cited below, includes these alluvia amongst the interglacial deposits; and in the present year we have an interesting essay on the same subject by the accomplished secretary of the Anthropological and Archæological Congress, which met last month in Paris. M. Boule correlates[5] the palæolithic cave- and river-deposits of France with those of other countries, and shows that they must be of interglacial age. His classification, I am gratified to find, does not materially differ from that given by myself a number of years ago. He is satisfied that in France there is evidence of three glacial epochs and two well-marked interglacial horizons. The oldest of the palæolithic

[1] *Archiv für Anthropologie*, Bd. xv., Heft 3, 1884.

[2] Rothpletz: *Denkschrift d. schweizer. Ges. für d. gesammt. Nat.*, Bd. xxviii., 1881.

[3] Andreæ: *Abhandl. z. geolog. Specialkarte v. Elsass-Lothringen*, Bd. iv., Heft 2, 1884.

[4] Pohlig: *op. cit.*

[5] Boule: *Revue d'Anthropologie*, 1889, t. I.

stages of Mortillet (CHELLÉENNE) culminated according to Boule during the last interglacial epoch, while the more recent palæolithic stages (MOUSTÉRIENNE, SOLUTRÉENNE, and MAGDALÉNIENNE) coincided with the last great development of glacier-ice. The palæolithic age, so far as Europe is concerned, came to a close during this last cold phase of the Glacial period.

There are many other points relating to glacial geology which have of late years been canvassed by continental workers, but these I cannot discuss here. I have purposely, indeed, restricted my remarks to such parts of a wide subject as I thought might have interest for glacialists in this country, some of whom may not have had their attention directed to the results which have recently been attained by their fellow-labourers in other lands. Had time permitted I should gladly have dwelt upon the noteworthy advances made by our American brethren in the same department of inquiry. Especially should I have wished to direct attention to the remarkable evidence adduced in favour of the periodicity of glacial action. Thus Messrs. Chamberlin and Salisbury, after a general review of that evidence, maintain that the Ice Age was interrupted by one chief interglacial epoch, and by three interglacial sub-epochs or episodes of deglaciation. The same authors discuss at some length the origin of the löss, and come to the general conclusion that while deposits of this character may have been formed at different stages of the Glacial period, and under different conditions, yet that upon the whole they are best explained by aqueous action. Indeed a perusal of the recent geological literature of America shows a close accord between the theoretical opinions of many trans-atlantic and European geologists.

Thus as years advance the picture of Pleistocene times becomes more and more clearly developed. The conditions under which our old palæolithic predecessors lived—the climatic and geographical changes of which they were the witnesses—are gradually being revealed with a precision that only a few years ago might well have seemed impossible. This of itself is extremely interesting, but I feel sure that I speak the conviction of many workers in this field of labour when I say that the clearing up of the history of Pleistocene times is not the only end which they have in view. One can hardly doubt that when the conditions of that period and the causes which gave rise to these have been more fully and definitely ascertained we shall have advanced some way towards the better understanding of the climatic conditions of still earlier periods. For it cannot be denied that our knowledge of Palæozoic, Mesozoic, and even early Cainozoic climates is unsatisfactory. But we may look forward to the time when much of this uncertainty will disappear. Meteorologists are every day acquiring a clearer conception of the distribution of atmospheric pressure and temperature, and the causes by which that distribution is determined, and the day is coming when we shall be better able than we are now to apply this extended meteorological knowledge to the explanation of the climates of former periods in the world's history. One of the chief factors in the present distribution of atmospheric temperature and pressure is doubtless the relative position of the great land and water areas; and if this be true of the present, it must be true also of the past. It would almost seem then as if all one had to do to ascertain the climatic condition of any particular period was to prepare a map, depicting with some approach to accuracy the former relative position of land and sea. With such a map, could our meteorologists infer what the climatic conditions must have been? Yes, provided we could assure them that in other respects the physical conditions did not differ from the present. Now there is no period in the past history of our globe the geographical conditions of which are better known than the Pleistocene. And yet when we have indicated these upon a map we find that they do not give the results which we might have expected. The climatic conditions which they seem to imply are not such as we know did actually obtain. It is obvious, therefore, that some additional and perhaps exceptional factor was at work to produce the recognised results. What was this disturbing element, and have we any evidence of its interference with the operation of the normal agents of climatic change in earlier periods of the world's history? We all know that various answers have been given to such questions. Whether amongst these the correct solution of the enigma is to be found time will show. Meanwhile, as the

hypothesis and theory must starve without facts to feed on, it behoves us as working geologists to do our best to add to the supply. The success with which other problems have been attacked by geologists forbids us to doubt that ere long we shall have done much to dispel some of the mystery which still envelopes the question of geological climates.

The following Report and Papers were read:—

1. *Ninth Report on the Earthquake and Volcanic Phenomena of Japan.* See Reports, p. 295.

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2. *The Bandaisan Eruption, Japan, July* 1888.
By C. MICHIE SMITH, *B.Sc., F.R.S.E., F.R.A.S.*

Bandaisan is a mountain in Japan lying in Lat. 37°36′ N. and Long. 140°6′ E. Before the eruption of July 15, 1888, there were three principal peaks—Obandai and Kobandai, each about 6,000 feet high, and Kushigamine about 5,300 feet high. The general result of the eruption was to blow away 1,587,000,000 cubic yards of the top of Kobandai and scatter it over an area of some twenty-seven square miles.

Immediately after the eruption Professor Sekiya and Mr. Kikuchi were deputed to make a survey of the region affected, and their report has been published in Tokio in the 'Journal of the Science College,' vol. iii., part 2, and in the 'Trans. Seis. Soc. of Japan.' Perhaps the most striking feature of the whole eruption, which was due simply to a vast explosion of steam, was the way in which the shattered fragments of Kobandai poured down from the mountain in two great earth-torrents, at a speed estimated by Professor Sekiya at 48 miles an hour. One of these—the smaller—was formed by materials projected over the shoulder of Kushigamine and poured down the valley of the Biwasawa in a south-easterly direction. The larger stream went nearly due north, burying a number of villages, and, for a time, damming up the Nagasegawa. The photographs shown illustrated some of the more interesting features of the eruption. The series of fifteen large pictures was taken by Professor W. K. Burton immediately after the eruption; the series of smaller ones was taken by the author ten months later. The former show the crater with the steam-jets still in very vigorous action, and give some excellent views of the earth-torrents and of the damage done by them. They show, amongst other things, the way in which the torrent flowed over obstacles—in one case a hill nearly 200 feet high—and up the sides of the hills which it struck at an angle. The second series show mainly the results of weathering and the action of flowing water on the earth streams and crater walls. The first three were taken on the Mine stream. These show how the Biwasawa, which is only a small rivulet, has already cut a deep channel through the loose earth. In one place where it was measured the channel was 80 feet deep and 80 feet wide at the top; in other parts the depth was estimated at from 120 to 150 feet. No. 4 shows a part of the ruined forest above Nakanoyu. The forests all round, where not protected by hills, were shattered mainly by a storm of stones of all sizes projected by the explosion. Most of the trees were overturned and the remainder were stripped of their leaves and twigs, and even of the bark, on the side facing Kobandai. The density of the stone-storm may be estimated by the fact that seventy-five marks of blows were counted on a quarter of a square foot of one of the tree-trunks still standing near Numanotaira. The remaining photographs were taken in the crater, and show its appearance after the action of rain, frost, and snow during the winter. The steam jets are seen to be much less active than they were; the walls are much covered with loose débris; and the sharp, conical mounds, which formed a striking feature last year, are now much smoothed and rounded.

The specimens shown were chiefly interesting as illustrating the way in which the rocks have been decomposed by the action of steam, a fact which must not be overlooked in estimating the causes leading to the explosion.

3. *Terrestrial Magnetism as modified by the Structure of the Earth's Crust, and Proposals concerning a Magnetic Survey of the Globe.*[1] *By* Dr. EDWARD NAUMANN.

The author compared the investigation of the earth's structure by magnetism with the use of light in crystallography, and referred to a memoir in which he has given a number of instances where the distortion of magnetic curves is caused by clefts in the crust, and proved that so-called 'rock magnetism' does not produce this distortion. After a historic review of early magnetic surveys, he quoted 'Locke's Magnetic Sections across the Hudson,' Nipher's 'Magnetic Survey of the State of Missouri, and the Magnetic Structure of the Himalayas, Carpathians and Erzgebirge,' to show the influence of igneous rocks and mountain upheavals on the magnetic lines. In his own magnetic and geological survey of Japan, the author shows the most remarkable correspondence between the lines of equal declination and the lines of geological structure, the very irregularities being intimately connected with the abnormal curvature of the folds; and as a typical instance he mentioned that the direction of the lines is strongly influenced by the course of the Fossa Magna, a great fissure extending from the Pacific to the Japan Sea coast, along which a number of volcanoes have sprung up, and which turns back the long series of folds which run in the general direction of the islands. A longitudinal fissure intersects this, and from both large quantities of molten matter have been ejected, with the result, in the author's view, of influencing the earth-currents, and consequently the magnetic needle. The rest of the paper was taken up with a reply to Dr. Knott's criticisms and an appeal for an international congress on the subject of a magnetic survey, which might be held in London at or about the time of the next British Association meeting. Such a survey would require in Japan 1,800 stations, in Germany 2,500, and in Great Britain 1,500.

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4. *Notes on the numerous newly discovered fossil footprints on the Lower Carboniferous Sandstones of Northumberland near Otterburn. By* Alderman T. P. BARKAS, *F.G.S.*

The object of these brief notes was to record the discovery of numerous and varied ichnological impressions on the carboniferous sandstones of Northumberland, and to make generally known a rich and almost unknown field for ichnological research in the near neighbourhood of the locality in which the annual meeting of the British Association is being held for the present year.

The author in the introduction to his paper traced the history of ichnology from the footprints discovered on the new red sandstone rocks of Scotland in 1828, the labyrinthodont marks in 1834, the numerous ichnological impressions on Permian rocks in the United States of America, by Dr. Deane and Dr. Hitchcock, between 1836 and 1844 (and published in the 'American Journal of Science'), and further ichnological discoveries by Dr. Dawson, Sir W. E. Logan, Mr. Brown, and Mr. G. W. Smith, down to 1884.

The footprints described by the writer were discovered by the late Mr. R. B. Sanderson, in 1871, since which time the author has frequently visited and searched the locality, which is on the Northumberland Moors, near Otterburn, at a height of 900 feet. Very numerous and varied impressions have been found, consisting of the footmarks of four, three, and two toed creatures perfectly new to science; slabs containing illustrations of each were placed on the lecture table for examination, and the paper was illustrated by graphic sketches on the blackboard. The district was said to be very rich in ichnological remains, and ardent geologists were urged to enter upon an early investigation of the locality.

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[1] Published *in extenso* in the *Geol. Mag.* for November and December 1889, pp. 486-490, 535-544.

5. *The Physiography of the Lower Trias.*[1] *By* T. Mellard Reade, *C.E.*, *F.G.S.*

After an introduction describing the various views held by geologists as to the origin of the Triassic rocks of Britain, the author stated that circumstances have lately provided an opportunity for a detailed examination by him of considerable areas of the Trias in the North-West of England. As a result of this he has been drawn towards a consideration of the attractive speculations on the origin of these rocks which have emanated from various geologists.

Describing the lacustrine theory suggested by the late Mr. Godwin-Austen and supported by Sir Andrew Ramsay, the author agrees with Professor Bonney that it does not account satisfactorily for the extensive areas of marine current-bedded sandstones constituting the base of the Trias, and known as the Bunter.

He considers that the prevalence of pebble-beds in these rocks, as well as the absence of thick beds of marl, is inconsistent with such an origin. Further, referring to the sub-aërial river delta theory brought forward in substitution by Professor Bonney, he contends that, while explaining the deposition of current-bedded sandstones, there is no evidence of the existence at the time of such peculiar physiographical conditions as would be required for the building up of a sub-aërial delta of sand from 1,200 to 2,000 feet thick.

Such a delta would require to be fed from a high plateau or from Alpine granitic ranges, of the former existence of which we have no evidence. The author considers, from his studies of mountain ranges, that such a permanent feature of the earth's surface, had it existed, would not have so totally disappeared, while lesser ranges like the Pennine Chain have survived.

It is also pointed out that the rivers of Asia and Africa feeding deltaic sands, which the Bunter is compared to, frequently disappear in them by absorption and desiccation leaving saline deposits, while in the Bunter of the North-West of England there is little or no evidence of such conditions having obtained.

In suggesting another possible origin for the Bunter sandstones, it is pointed out that the Triassic rocks which are preserved appear to lie in the deeper part of the basins in which they were deposited, and that there has been here and there a remarkable preservation of the ancient orographic features, modified, it is true, by folding and faulting. In support of this it is shown that a subsidence of 400 feet would cover most of the Trias by the sea, which would approximately follow in its margin the present Triassic boundaries.

Where the Triassic deposits are bounded by the mountains of Wales and by the Pennine Chain or other high land, the overlapping of the present boundaries by the sandstones was limited; but there is every reason to suppose that there was a wide extension of them occupying the site of the Irish Sea. It is contended that these features most probably represent subsided valleys or arms of the sea previously occupied by partly denuded Permians; and the author thinks that tidal action is capable of selecting the materials for and constructing, under conditions pointed out, thick massive beds of sandstone, current-bedded, with intercalated conglomerate beds or with well-rounded quartzite pebbles distributed sparsely through the rock or in nests, as found in all these forms in the Bunter sandstones. Two papers by the author on Tidal Action as a Geological Agent in the 'Philosophical Magazine,' and the 'Proceedings of the Liverpool Geological Society' were referred to in explanation of the physical questions involved.

It is suggested that a granitic area, such as would be exposed now by an elevation of, say, 1,000 feet, occupying the site of the English Channel, together with the Old Red Sandstone beds of the anticlinal axis connecting the Mendips with the Belgian coal field, reinforced by the sand derived from the immense destruction of carboniferous sandstones which, we know, has taken place in the Pennine Chain and in other areas, together with the denudation of the Old Red of Hereford, may have supplied the materials for the Triassic rocks, which were distributed and built up by tidal action in straits, seas, and bays. The details of the process

[1] Published *in extenso* in the *Geol. Mag.* for December 1889, pp. 549–558.

of elimination of the quartz granules, their distribution over great areas, and frequent rounding by wind action are fully discussed.

It is also suggested that the quartzite boulders and pebbles have most probably travelled from the South, as they are less in number and smaller in Lancashire than in the conglomerates of Market Drayton.

To the objection that no marine fossils are present in the Bunter sandstone, the author, while allowing a considerable amount of force to the circumstance, points out that it is only negative evidence, proverbially unsafe, and sets against it the absence of saline deposits, which we would expect to occur on the sub-aërial delta theory.

Finally, it is shown that the distribution of the lower Triassic sandstones is inconsistent with a fluviatile origin.

FRIDAY, SEPTEMBER 13.

The following Papers were read:—

1. *On the Origin and Age of some of the Crystalline Schists of Norway. By* ARCHIBALD GEIKIE, *F.R.S., Director-General of the Geological Survey.*

The author described the chief results of a recent journey made by him in Norway for the purpose of comparing the Archæan and Palæozoic metamorphic rocks of that country with those of the Highlands of Scotland. He directed his attention to the districts where recognisable fossils occur in strata surrounded by crystalline schists, and where he hoped that the actual relations of the fossiliferous sedimentary formations and the schistose rocks could be definitely ascertained. These districts were, 1st, the country lying to the south and east of Trondhjem embracing the lower parts of the valleys of the Örkla and Gula rivers; and, 2nd, the southern portion of the peninsula of Bergen.

The Trondhjem region has been described and mapped by Kjerulf and his associates in the Geological Survey of Norway, and portions of it have been described by Professor Brögger and others, but their observations were made before the recent development of our knowledge regarding the problems of metamorphism. There was, therefore, room to believe that a re-examination of the area, in the light of recent experience in the Scottish Highlands, might lead to a clearer apprehension of the nature and order of the rocks. Accordingly the author first studied the fossiliferous series of strata, and worked outwards from these into the adjacent metamorphosed masses. The rocks which contain fossils in some of their members consist of shales, slates, mudstones, limestones, sandstones, breccias, and conglomerates, an assemblage of ordinary sedimentary accumulations precisely similar in character to those that compose the older Palæozoic formations in Britain. They have, however, been very greatly disturbed. Over wide areas they are on end or placed at high angles; they have been so folded and fractured that without detailed mapping it is impossible to determine satisfactorily their order of sequence. The fossils obtained from certain portions are Upper Silurian types, while those from other parts are Lower Silurian. The author traced these fossiliferous rocks southwards, and found evidence of increasing mechanical deformation and metamorphism. He ascertained that at their base they are interstratified with and rest upon an important series of volcanic rocks—basic lavas of the diabase type with coarse agglomerates and fine tuffs—which, where they have come within the influence of the regional disturbances, have been crushed and converted into unctuous chloritic schists. A series of specimens was exhibited illustrating the stages of metamorphism from an amorphous igneous rock into a perfect schist, the change being sometimes shown even in a single hand-specimen. The volcanic zone is succeeded by a great series of sandstones, grits, quartzites, slates, and schists. Among these some of the most conspicuous bands are black,

carbonaceous, and pyritous, like the alum-slates of Southern Norway. From some of these bands graptolites are reported to have been obtained further to the south-east. The whole of this great series of rocks is found to be progressively more crumpled and crystalline as it is followed southward, until it becomes essentially a group of twisted mica-schists (sometimes with large garnets) in which, however, the black pyritous bands, now also converted into mica-schists, can be easily recognised. These stages in metamorphism were illustrated by a series of specimens collected along a horizontal distance of six miles in the Gula Valley.

The author pointed out the close resemblance of these Norwegian rocks to those that constitute the main mass of the central and southern Highlands of Scotland. He showed that they could be easily distinguished from the Archæan series in both countries; that they were essentially of sedimentary origin but with important volcanic intercalations; that the fossil evidence from Norway proved them in that country to be of Silurian age; and that a similar conclusion as to the age of those in Scotland might be drawn from the stratigraphy of the Highlands.

The Bergen area has been excellently mapped and described by Dr. Reusch, who first discovered fossils there in a fine mica-schist or phyllite. The author succeeded in obtaining fossils from all the localities mentioned by the Norwegian geologist, and verified his observations as to the intercalation of the fossiliferous rocks among bands of metamorphosed sedimentary strata and of gneisses and more or less deformed igneous masses. The rocks, approximately vertical, are arranged in parallel strips having a general north-easterly strike. Their relations to each other were not very clearly displayed in the sections which the author examined. They appeared, however, to be thrust over each other, wedges of possibly Archæan rocks being thereby intercalated between obviously clastic beds. The main point of interest, however, was perfectly clear—viz., that a rock containing Upper Silurian fossils had become a finely puckered or frilled mica-schist or phyllite. The regional metamorphism in the Bergen district was thus proved to have taken place after some epoch in the Upper Silurian period—a conclusion in harmony with recent observations of the Geological Survey in the west of Ireland.

2. *Dynamic Metamorphism of Skiddaw Slates.* *By* J. E. MARR, *M.A.*, *Sec.G.S.*

In the belt of Skiddaw slates running along the west side of the Crossfell Escarpment from Melmerby to Roman Fell, several large masses of quartz veins occur, trending generally in a W.N.W.–E.S.E. direction. The best exposure is on the east side of Brownber. Here the large quartz veins were evidently intruded along bedding planes before the main folding took place. They are now extremely contorted, and the slates have undergone alteration, being converted into a rock, composed largely of mica and secondary quartz, and exhibiting 'Ausweichungs-clivage'—in fact, a mica-schist.

Many cubes of pyrites are scattered through the rock, and have been slightly deformed, with formation of a fibrous mineral around the crystals.

The slates are not greatly altered, except in belts where the quartz veins come, and as these were (as above stated) formed before the principal folding, it would appear that the alteration of the slates is due to the differential movement produced between the hard quartz and soft slate, as shown by the universal slickensiding of the divisional planes.

3. *On the Lower Silurian Felsites of the South-East of Ireland.*[1] *By* Dr. F. H. HATCH.

In this paper are communicated twelve analyses, by Mr. J. Hort Player, of felsites from the Lower Silurian (Bala) beds of the counties Wicklow and Waterford. The main point brought out by these analyses is the almost entire absence

[1] Published *in extenso* in the *Geol. Mag.* for December 1889, pp. 545–549.

of lime and the presence of potash and soda in varying proportions. According to the relative proportions of the alkalies the rocks are roughly separated into three groups:—

(i.) Those in which there is a large excess of potash over soda, the latter being present only in the smallest quantity (*potash-felsites*).

(ii.) Those in which the soda, though present in considerable quantity, is yet subordinate to the potash (*potash-soda-felsites*).

(iii.) Those in which the soda is in excess (*soda-felsites*).

Group i. comprises felsites containing few or no porphyritic crystals: they are composed mainly of a crypto-crystalline or felsitic aggregate of quartz and felspar. The few porphyritic crystals are not striated and consist of orthoclase.

Groups ii. and iii. embrace felsites in which a striated porphyritic constituent is abundant. The felspar of the crypto- to micro-crystalline groundmass, however, is most probably orthoclase, and it seems likely that the fluctuation in the percentages of potash and soda in these rocks may be due to a variation in the relative proportion between a porphyritic albite-felspar and the orthoclase-felspar of the groundmass. On the other hand it is not impossible that we may have to deal with a felspar belonging to a triclinic potash-soda series (the anorthoclase series of Rosenbusch).

The modern equivalents of these ancient felsites are the rhyolites or liparites and pantellerites, which have also been shown to be divisible into potash and soda series.

Some of the rocks in question show indications of having consolidated as true glasses (pitchstone or obsidian).

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4. *The Age of the Granites of Dartmoor and the English Channel.*[1] *By* A. R. Hunt, *M.A.*, *F.G.S.*

The examination of the crystalline and other rocks trawled in the English Channel off the coast of South Devon has been this year brought to a close by the sale of the fishing vessel which has for the past ten years supplied most of the specimens.

Thirty-two crystalline rocks trawled in the Channel have been microscopically examined from time to time by the late Mr. E. B. Tawney or Professor Bonney, and the analyses published in the 'Transactions of the Devonshire Association.'

On comparing the granitoid rocks from the Channel, with nine specimens of granite, and of veins intersecting the granite or the adjacent sedimentary rocks from the eastern flank of Dartmoor, the following points of difference may be noted:—

Tourmaline has not been detected in the Channel rocks, but abounds in Dartmoor. Hornblende is absent from the Dartmoor granites but is often abundant in those from the Channel.

In the nine slides examined from the eastern border of the moor, as well as in one derived from its south-western border, cubic crystals (presumably chloride of sodium) are present in fluid inclusions in the quartz.

In the fluid inclusions in the Channel rocks cubic crystals have not been detected. Hence it would appear that the included fluid is water in the case of the Channel rocks, and brine in the case of those from Dartmoor containing cubic crystals.

The bubbles in the Channel rocks are usually active, or at least easily moved: those in the Dartmoor rocks are usually sluggish, if not immovable.

Among the Channel rocks are gneisses both typical and hornblendic, and rocks intermediate between granites and gneisses.

The Dartmoor granites are not gneissic in character.

Many of the Channel rocks indicate compression. The condition of the Dartmoor granite is suggestive rather of fracture, with local crushings giving rise to heat

[1] *Trans. Devon. Assoc.* vol. xxi. p. 238.

with consequent reconstitution of the granite in the presence of salt water, with injection into the fissures.

There has been no evidence of veins in the trawled Channel rocks.

The Dartmoor granites abound in veins both injected and infiltrated. The felspathic matter in the infiltrated veins occasionally presents indications of the polysynthetic twinning of plagioclase.

The tourmaline in the crystalline veins is occasionally the straw-coloured idiomorphic variety: that in the aqueous veins is of the radiating dark-green variety (both occur together in Luxulyanite).

On the southern borders of Dartmoor in the culm-measures, chiastolite (= andalusite) is developed—sil. 36·8, al. 63·2,[1] sp. gr. 3·16—3·2.[2]

On the northern borders of the Channel, *i.e.* in the Bolt Head, mica schist, kyanite (= disthene) is developed—sil. 36·8, al. 63·2,[1] sp. gr. 3·5—3·7.[2]

Chiastolite and kyanite having the same chemical composition, the heavier kyanite may be taken to indicate a region of greater compression, where it occurs, viz. the borders of the Channel crystalline rocks.

The Channel granites and gneisses have been considered by experts archæan.

The Dartmoor granites have been commonly considered post-carboniferous on the evidence of the veins injected into the culm-measures.

The facts above noted seem to indicate that the culm-measures on the flanks of Dartmoor were deposited on an ocean bed of pre-Devonian granite, and that in post-carboniferous times the Dartmoor area, by a heavy north and south squeeze, was elevated and fractured, whilst still beneath the sea, thus giving access to the superincumbent salt water. The Channel area being depressed would by the same earth movement undergo heavy compression at its surface which would prevent any ingress of salt water.

On this hypothesis the Channel and Dartmoor granites are both pre-Devonian, and probably archæan. The former having occasionally been altered by compression, the latter by moderate heat in the presence of salt water. The one chiefly affected by compression, the other by solution, but both having undergone their mineral transformations, whether dynamical or chemical, or both combined, before emerging from the waters of the post-carboniferous sea.

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5. *The Island of Paros, in the Cyclades, and its Marble Quarries.* *By* ROBERT SWAN, *F.C.S.*

The island of Paros is 11 miles long and 8 miles broad at its widest part. There is a broad belt of nearly level land round the coast; but the interior is mountainous, rising to a height of 2,530 feet at Mount St. Elias (probably the ancient Mount Marpessus).

The northern and western parts consist of schist and gneiss, granite appearing also in the environs of Parekhia. The southern part of the island consists chiefly of crystalline limestone. There is no evidence here of the age of this limestone; but that of Attica is now known to be Cretaceous, and probably that of the Cyclades is of the same age. The finest statuary marble, or *lychnitis,* varies from 5 to 15 feet in thickness at the quarries of St. Minas; it occurs in a bed of coarse-grained white marble, with bluish-black veins. The coarse marble becomes dark in colour near the lychnitis, both above and below it, and thus the layer of statuary marble is distinctly marked off. The dark colour is due to traces of binoxide of manganese and magnetic oxide of iron. It seems probable that the impurities have been withdrawn from the lychnitis and have become concentrated near the edges of the adjacent seams of limestone.

The rocks are much disturbed and folded, and often dip at high angles. The

[1] *System of Mineralogy*, Dana, pp. 372, 375.

[2] *Microscopical Physiography of the Rock-forming Minerals*, Rosenbusch, pp. 194, 314.

[3] *See B. A. Report* 1888, p. 520.

ancients avoided the marble lying near the axis of elevation, that being of less good quality than in other parts. A Greek company formed a few years back to work the marble attacked it here, where it could be got at least expense; this discredited the marble in the market, and the company failed, having spent over 160,000*l.* in a railway, landing-pier, and elaborate installation of various kinds.

There is a good deal of excellent coloured marble on the island; but not having been used by the ancient Greeks this is little known.

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6. *Preliminary Note on the alleged Occurrence of Fossils in the Crystalline Schists of the Lepontine Alps. By* Professor T. G. BONNEY, *D.Sc., F.R.S., F.G.S.*

The author, in company with Mr. J. Eccles, F.G.S., has recently examined some of the sections which have been asserted to demonstrate the occurrence of fossils in crystalline schists of the Alps, and consequently the Mesozoic age of a large part of that group of schists which appears to occupy the highest position in the crystalline series. Of these sections the most important are those on either side of the top of Lukmanier Pass (Scopi, &c), on the Nufenen Pass, in the Val Piora and in the Val Canaria. He has arrived at the following conclusions:—

1. The section in the Val Canaria, which is supposed to demonstrate that black-garnet-schists, kyanite schists, calc-mica schists, &c., overlie and are enfolded in rauchwacké (probably of Triassic age) has been misunderstood. It is not a simple fold, but one broken up by a series of thrust-faults.
2. In the Val Piora crystalline schists, identical with the above, are inseparably associated together, and are disconnected from the rauchwacké, which here, as in the Val Canaria and elsewhere, contains fragments of various members of this series.
3. The supposed schists with minerals like garnet and staurolite, which on both sides of the Lukmanier Pass and on the Nufenen Pass contain fossils (belemnites, &c.), are quite distinct from the above-named group of schists; the minerals present therein are in a very different condition, and, so far as the author could judge from field work, suggest a derivation from that group. Such similarity as there is between the two groups may be due partly to this cause, partly (but this only locally) to exceptional pressure having to some extent obliterated the distinctive characteristics—in the one case of a crystalline schist, in the other of an ordinary sedimentary rock.
4. Additional evidence has been obtained, not in this district only, in support of the opinion already expressed by the author, that the crystalline schists of the Alps existed as crystalline schists anterior to any rock which can be recognised as of Mesozoic or even of Palæozoic date.

When the author has completed the microscopic examination of the specimens which he has collected, he will communicate the details of this and of his field-work to the Geological Society of London.

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7. *Exhibition of Specimens of Belemnites from Luckmanier. By* W. W. WATTS, *M.A., F.G.S.*

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8. *The Effects of Pressure on Crystalline Limestones.*[1] *By* Professor T. G. BONNEY, *D.Sc., F.R.S., F.G.S.*

The author stated that the Mesozoic limestones of the Alps do not seem more distinctly crystalline than the later Palæozoic limestones of Britain, but that the

[1] Published *in extenso* in the *Geol. Mag.* for November 1889, pp. 483–486.

crystalline structure of limestones associated with the crystalline schists appears to bear a certain relation to that of the schists. To the latter rule, however, exceptions at first sight seem not infrequent, but microscopic examination shows that these are due to the original coarser structure being to a great extent obliterated by crushing. The well-known Tiree marble, where commonly rather large grains of sahlite occur in a seemingly compact matrix of calcite, is found to be an instance of the same, and microscopic examination shows that the whole rock was once coarsely crystalline. The author concludes that, in limestones, pressure alone is a comparatively minor agent in producing crystallisation, while it often renders those which were once crystalline more fine-grained in structure.

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9. *The Amygdaloids of the Tynemouth Dyke.*[1] *By* J. J. H. Teall, *M.A., F.G.S.*

In a paper published in the 'Quarterly Journal of the Geological Society' for 1884,[2] I gave some account of the Tynemouth Dyke. In that paper, however, I omitted to describe one feature, connected with the microscopic structure of the dyke, because at the time of writing I did not understand it. A short time ago I had occasion to re-examine my preparations, when my attention was again directed to the feature in question; and this time an explanation suggested itself which appears to be in every respect satisfactory. The main object of this communication is to supplement my already published description by giving an account of the feature to which I have referred, and which may be briefly described as the occurrence of spherical patches of interstitial matter.

At the time of my residence at Tynemouth (1882) the dyke was exposed in the angle formed by the breakwater and the cliff on which the Priory stands, and also in the cutting close to the railway station. The rock of which the dyke is composed varies somewhat in character owing to the presence or absence of porphyritic felspars and small spherical amygdaloids. A typical specimen may be said to consist essentially of porphyritic crystals, or rather crystalline aggregates of a felspar closely allied to anorthite, embedded in a dark, finely crystalline groundmass, composed of augite, lath-shaped felspars, and interstitial matter.

The porphyritic constituents undoubtedly belong to the earliest phase in the consolidation of the original mass of molten matter. They consist, as a rule, not of single crystals, but of two or more individuals. Where the individuals of one and the same group are in contact with each other they exhibit no trace of crystalline form,[3] but where they are in contact with the groundmass they are bounded by definite faces. In other words, the internal relations of the individuals forming a group are those of plutonic rocks (*e.g.*, Gabbro), whereas the external relations of the same individuals are those of volcanic rocks. This, of course, is in strict accord with the general view that the porphyritic constituents have been developed under plutonic conditions. An examination of the porphyritic aggregates under crossed Nicols reveals the fact that the felspar substance to which the external idiomorphism is due differs from that forming the central portions. This, taken in connection with the fact that the augite-grains of the groundmass are occasionally included in the peripheral zone of the porphyritic groups, justifies the conclusion that such external form as the individuals possess was given to them at a later stage in the history of the consolidation of the rock than that at which the groups themselves were formed, and also under different physical conditions.

The augite is pale in colour, and occurs in grains or granular aggregates. It is occasionally penetrated by the lath-shaped felspars, and must, on the whole, have been formed after them.

The lath-shaped felspars call for no special description. They frequently show multiple twinning of the usual type.

[1] Published in *Geol. Mag.* for November 1889, pp. 481–483.
[2] *Petrological Notes on some North of England Dykes*, vol. xl.
[3] See fig. 1, plate XIII., accompanying the paper already referred to.

The interstitial matter contains extremely minute microlites and skeleton crystals of felspar, grains and skeletons of magnetite, and an indistinct brownish granular substance. It is not possible to recognise, even with the highest powers, any true glass. This interstitial matter occurs in more or less angular patches wedged in between the other constituents, and gives to the rock the structure for which Professor Rosenbusch has proposed the term *intersertal*. The rock itself would be termed by this author a tholeite.

Now, the peculiar feature to which I wish to call special attention is the occasional occurrence of spherical patches of interstitial matter. These appear in the thin sections—and they have only been recognised in the sections—as circles. How are these spherical patches to be accounted for? An answer to this question is found by studying the amygdaloids, which have been already referred to as occurring in certain portions of the dyke. Microscopic examination enables us to determine the precise stage in the history of consolidation at which the vesicular cavities, now for the most part filled with carbonates with or without a narrow border of chalcedony, were formed. Their development evidently displaced the lath-shaped felspars, for these are often arranged tangentially with reference to the bubbles; but it produced no effect on the disposition of the constituents of the interstitial matter. It appears, then, that the gas bubbles were produced after the formation of the porphyritic constituents, the augite and the lath-shaped felspars, but before the consolidation of the interstitial matter. It is possible that their development was due to the relief of pressure consequent on the rise of the semi-liquid mass in the crack. If so, then they are analogous, so far as their mode of formation is concerned, to the bubbles which arise in the contents of a soda-water bottle as the cork is partially removed.

Now, the spherical patches of interstitial matter agree in form and size with the amygdaloids, and to account for them we have only to suppose that the portion of the mass which was liquid at the time of their formation, oozed into some of the vesicles owing to the absorption, escape, or condensation of the gas. That this is the true explanation is proved by the occurrence of cavities which have been only partially filled up.

The last act to which we have to call attention was the filling up of the cavities remaining empty after final consolidation with chalcedony and carbonates.

We may summarise the history of the rock so far as it is recorded in microscopic structure as follows:—

1. Development of granular aggregates of a felspar allied to anorthite under plutonic conditions.
2. Addition of felspar substance to the external portions of the granular aggregates, and the consequent production of crystalline form.
3. Development of lath-shaped felspars.
4. Separation of augite.
5. Formation of vesicles owing to the separation of gas from the magma.
6. Partial or complete filling up of some of these vesicles with interstitial matter.
7. Consolidation of the interstitial matter.
8. Filling up of the vesicles remaining empty after final consolidation with carbonates.

10. *Observations on the Greenland Ice-sheet. By* Dr. Fridtjof Nansen.

The scientific results of the expedition cannot at present be stated, many observations not having been worked out by the special *savants* to whom they have been submitted. There are, however, some geological points which even at present are prominent, and though I am no geologist, I shall mention some of those which, according to my view, are of interest.

The shape of the inland ice is of importance. Many geologists have suggested that the interior of Greenland is ice- and snow-clad, but there have been others who were of the opinion that it was not snow-clad; amongst the latter the famous Nordenskiöld. This prominent explorer of Arctic regions did not believe that the

ice-covering extends throughout Greenland from coast to coast, notwithstanding that nobody had seen the boundaries of the 'ice-desert.' He even believed 'that it in most cases is a physical impossibility that the interior of a large continent should be completely covered with ice under the climatic circumstances which occur on our planet south of 80° latitude.' As to the interior of Greenland, he says that it is even easy to prove that the conditions for the forming of glaciers cannot occur there, if the surface of the land does not gradually and regularly rise from the east coast as well as from the west coast towards the centre. But, in Nordenskiöld's opinion, no continent orographically known on our earth has such a shape. Greenland he correctly supposes to have an orographical structure very much like Scandinavia, and, let us also say, like Scotland—that is, it consists of mountain ranges and peaks, separated by deep valleys and plains, and in such a country most of the rain and snow must fall in the neighbourhood of the coasts, whilst only dry and warm winds reach the interior, so that there cannot be moisture enough to form a glacier here.

I will not here criticise Nordenskiöld's theories. The expedition from which I have just returned has, in my opinion, fully proved that they cannot be right as far as concerns Greenland. It has, I believe, settled the fact that this part of Greenland is not only ice- and snow-clad, but has a mighty shield-shaped covering of snow and ice, under which mountains as well as valleys have quite disappeared, and where you cannot even trace the configuration of the land and mountains. Whether this is also the case in the most northern parts of Greenland I dare not yet say; this must be decided by a new expedition, and I think the question to be of the highest interest. At present we will only consider the southern parts of Greenland.

The ice-covering has here, as already mentioned, the shape of a shield. Rather rapidly, but regularly, it rises from the east coast, reaches a height of 9,000 to 10,000 feet, is rather flat and even in the middle, and falls again regularly towards the west coast.

Considering this peculiar and regular shape of the ice, the first question which must force itself upon us is, What has occasioned this regular shape? What is the configuration of the land underneath?

I have heard geologists say that, judging from what has been observed by us, it is clear that Greenland is a tableland only, the exterior parts of which are excavated by the glaciers, so that fjords and valleys are formed, whilst the interior evidently has the shape of a high plateau, where no considerable valleys or mountains can be present, there being no glaciers to excavate the ground. But I think this conclusion is entirely false. I think that the shape of the surface of the inland ice is not at all caused by the configuration of the land underneath.

In the interior of Greenland there must be mountains and valleys, as well as near the coast. That there are on the coasts deep fjords and lofty mountains very like those of western Norway, and that they have just the same wild and prominent character in some places, we already know; they are perhaps even wilder than I ever saw them in my own country.

If we entertain the opinion that these fjords are excavated by the ice, we must also conclude that the same ice has been able to excavate valleys and to form mountains in the interior of the continent, although at a smaller degree. To this subject I shall, however, return a little later. I think, therefore, that we have no right to seek the reason of the shield-like shape of the ice in the configuration of the land underneath; the surface of the ice must have a shape of its own, which is given not by the land but by the meteorological circumstances. Nobody can deny that the ice must in some places be of an enormous thickness, as it fills the valleys and covers up all the mountains, and its thickness must evidently be regulated by the quantity of snow falling. This quantity must be largest towards the coasts, gradually diminishing towards the interior; it is consequently very likely that the ice has not its greatest thickness just in the middle of the continent, but rather on both sides towards the coasts. We might thus already *a priori* have expected to find the ice of a shape like that observed.

The surface of the snow-field in the interior is quite even and as it were polished.

It has a striking resemblance to the undisturbed surface of a frozen ocean, the long but not high billows of which rolling from east to west are not easily distinguishable to the eye.

The principal factor which makes this surface so remarkably even is the wind. The levelling influence of the wind may easily be studied in our Norwegian mountains in the winter; there it may be seen how its prevailing effect is to remove every prominence, the snow being carried from the mountains into the valleys to fill them and make the mountains disappear. This has of course also been the case in Greenland, only to a much higher degree, when its present glacial period commenced. The snow grew annually, gradually the valleys were filled up, the mountains disappeared, and the snow-field was produced which we now see.

The surface of the snow-field in the interior consists of soft, loose, and dry snow, which is easily moved by the wind. Even in midsummer there is no snow-melting of importance in this interior. Even with the six-feet sticks we use for *ski*-running I could not reach hard ice or snow underneath the soft layer. At intervals of six to ten inches quite thin ice-crusts occurred; between them there was, however, soft snow like that of the surface. These thin ice-crusts are evidently formed by the direct influence of the sun during midsummer. The sun is then, in the middle of the day, able to melt the surface of the snow a little; in the night, however, it freezes again. Whether these ice-crusts at certain intervals indicated annual layers of snow, or whether they only indicated heavy snowfalls during the summer, I am not able to decide. I am, however, inclined to the latter opinion—at all events, to some extent.

We had snow fall almost every day. When we compare this with the fact just stated, that there is no real snow-melting in the interior, it would seem as if we were obliged to conclude that the quantity of snow is still increasing in the interior of Greenland. This cannot, however, easily be the case—at all events, not in any considerable degree; for if it were so, the quantity of ice and snow must also increase towards the coasts.

Judging from the observations and measurements which during several years have been made on the west coasts of Greenland, it seems, however, as if the ice varies a little from one year to another, but that upon the whole its quantity keeps very nearly on the same level. We are not thus entitled to assume that the quantity of snow is increasing in the interior.

But what is the reason why it does not increase? As already mentioned, the snow-melting cannot be of any importance. The evaporation from the snow-surface cannot, in my opinion, be of much more importance, as it must be quite a trifle with such a low temperature of the air, and where on most days a little snow falls.

A factor of more importance is, I think, the snowdrifts occasioned by the wind, which most likely has a tendency to blow from the cold and high interior towards the lower and warmer coasts. In the middle of the continent the winds blow, however, in all possible directions, and thus, I think, even this factor is of no great importance. The principal factor to keep the level must, in my opinion, be the pressure which is produced within this immense layer of ice and snow. On one hand this pressure forces the ice downwards along the sloping sides of the mountains, through the valleys and towards the sea, into which it falls in form of ice-streams or glaciers, and is carried away in form of icebergs or is melted.

To a great many peoople it does not seem necessary that the ice must force its way to the coast in this manner, but I think that if we said that the interior of Greenland was filled or covered by an immense layer of pitch nobody would doubt that this would find its way to the sea; but there is really in that respect no great difference between these two materials; by the immense pressure the ice is probably made even more fluid than melting pitch.

But the pressure brings the ice to the sea not only in the form of ice, but also (and certainly in larger quantity) in the form of water. As is generally known, ice has the peculiarity that by pressure it can be transformed into water at temperatures lower than its common melting-point; in other words, pressure lowers the melting-point of the ice. I do not think, however, that it is principally in this manner the pressure contributes to the melting of the snow, as such a high pressure,

and consequently a very considerable quantity of snow and ice, is necessary to lower the melting-point of the ice only one degree. I think that the most important factor is the warmth produced by the pressure and friction. When such immense quantities of ice and snow as those in Greenland are in constant movement, it is evident that the pressure must give rise to an enormous friction, and in this way a considerable warmth must be produced. There is thus much reason to conclude that the deeper we go into the ice the higher the temperature we shall find, and at a certain depth the temperature of the ice must be about its melting-point, which consequently is somewhat lower than the ordinary freezing-point (*i.e.* zero of Centigrade).

Even if we neglect the fact that the temperature of the earth's crust rises everywhere when we penetrate deeply into it, it seems likely that in the depths of the inland ice of Greenland, especially where the ice touches the ground underneath, there is a considerable melting going on. It may be objected that nobody has observed this melting or even a rise in the temperature of the ice downwards. This is quite true, but good proofs that melting really goes on in the interior are the rivers, which, even in the middle of the cold Greenland winter, run out under the glaciers at the margin of the inland ice. I have observed such rivers myself; they were large even where there was no possibility of a melting on the surface of the inland ice.

For glacialists I think the observations made on this expedition must be of great interest, and that they must contribute largely to confirm many of the glacial theories.

The careful observation of a snow and ice covering like that of Greenland is, in my opinion, of great importance for the theory of the formation of valleys and fjords by the ice. The ability to excavate the ground underneath must be considerable in quantities of ice like those observed there. To me, it seems indeed natural that the more we study Greenland, its coasts, and its inland ice, the more convinced must we feel of the ability of the ice to form fjords and valleys to a great extent. Indeed, if we attentively study on the one hand the fjords and valleys of Greenland, with their many evidences of glacial influence, and on the other hand the inland ice, we can be in no doubt whatever that these are in a near relation to each other; and if we turn our eyes from Greenland to Norway and Scotland, we must grant that there are here similar formations.

In meteorological respects there are some observations of great interest. The very low temperature met with in the interior will be astonishing to most meteorologists; it does not seem to agree with the received meteorological laws—at all events, not at the first glance. The radiation of warmth from this immense snowfield, in such an altitude where the air is consequently very thin, must evidently have a great influence in lowering the temperature. The interior of Greenland must be the coldest place on earth hitherto known; it must be a kind of cold pole, from which the winds blow towards the coasts and the sea.

I think that this low temperature may throw a good deal of light on the much-discussed question, the cause of the great cold of the Glacial Period in Europe and North America, which at that time were covered with an ice-sheet similar to that we now see in Greenland. The best way of solving the problems of the Great Ice Age is to go and examine the places where similar conditions are now found, and no better place can be found than Greenland. But Greenland is a vast region; our expedition was the first to cross it, but I hope it will not be the last.

SATURDAY, SEPTEMBER 14.

The following Reports and Papers were read:—

1. *Report of the Committee for investigating the Flora of the Carboniferous Rocks of Lancashire and West Yorkshire*—See Reports, p. 69.

2. *Seventh Report on the Fossil Phyllopoda of the Palæozoic Rocks.*—See Reports, p. 63.

3. *Report on the Volcanic Phenomena of Vesuvius and its neighbourhood.*—See Reports, p. 283.

4. *On the Presence of Coral-like Forms in the Crystalline Limestone of Inishowen, Co. Donegal. By* Professor EDWARD HULL, *LL.D., F.R.S.*

The existence of peculiar coral-like forms in the limestone of Culdaff in North Donegal has long been known. The earliest notice of them is that by Mr. Patrick Ganley in 1856, who states that they may 'rationally be regarded as organic remains, and are probably referable to genera allied to such forms as *Halysites catenularis, Favosites Gothlandica*, or *Lithostrotion*' ('Journ. Geol. Soc. Dub.' vol. vii. p. 163). The late Professor W. King, of Galway, also regarded them as fossils, and this view was held by the late Mr. W. H. Baily, Palæontologist to the Irish Geological Survey, who identified some of the specimens as belonging to the genus *Halysites*.

A large number of these forms had been collected during the progress of the geological survey, and for the purpose of obtaining the views thereon of palæontologists in various countries, photographs had been taken and distributed by the author. Replies had now been received from several palæontologists of acknowledged authority, amongst whom may be mentioned Dr. Ferdinand Roemer of Breslau, Dr. Newberry, of the U.S. Geological Survey, Professor Dana, who examined them in company with Mr. Charles E. Beecher, Professor James Hall, author of the 'Palæontology of New York,' all of whom pronounce the specimens to be coralline. Dr. Newberry regards them as belonging to the American genus *Favistella*, and kindly forwarded specimens of this fossil from the Trenton limestone of America for comparison with those of Culdaff. In the opinion of the author, and of his colleagues of the Irish Survey, the identity of some of them is clear;—due allowance being made for the amount of alteration to which the Culdaff forms have been subjected.

On the other hand, Dr. Selwyn, Dr. Alleyne Nicholson, Professor Haddon, and some other British palæontologists, give only a hesitating assent to the view of their organic origin.

The officers of the Irish Survey, including the author, after a close and prolonged examination and comparison, are fully persuaded that the forms are coralline. One specimen, at least, appears identical with a specimen of *Favosites fibrosus* from the Lower Silurian beds of Co. Wexford, now in the collection of the survey; other forms apparently represent other species of (as Dr. Ferd. Roemer considers) *Favosites*, or of *Columnaria*. Should the organic origin of these fossils be established, as the author believed would be the case, the beds in which they occur must be referred to the Lower Silurian system.

Specimens and photographs were exhibited at the meeting.

5. *Exhibition of a small block of Magnetically Polar Diorite. By* Professor EDWARD HULL, *LL.D., F.R.S.*

6. *Note on the recent Exposures of Kellaway's Rock at Bedford. By* A. C. G. CAMERON, *F.G.S.*

Within the environs of Bedford, as well as higher up the valley, the basement beds of the Oxford clay are extensively dug, and this has resulted in laying bare an unsuspected development of Kellaway's Rock, the existence of which in Bedfordshire has not hitherto been recorded. The brick-fields and stone-pits adjoining

the town display about 40 feet of Jurassic strata, comprising upper and lower Oxford clay, with Kellaway's Rock between; cornbrash and great oolite limestone separated by a considerable thickness of purplish clay. Measured against the sombre hues of these clays, the tawny yellow of the Kellaway's rock shows to advantage at this section. Where the sand has been dug away, doggers of large dimensions, mushroom-like in shape, stand about, each as it were on a pedestal of its own, or put out their rounded forms from amongst the sand in which they lie. The outer coatings of these stones are loose, crumbly, and full of shells, while their interiors are made of hard, calcareous sandstone, with a considerable proportion of iron. The frequent occurrence of such hard masses amongst the sand seems to arrest the percolation of water, so that springs (more or less ferruginous) issue in the county that (judging by its protrusion hard by) must begin with the dogger. Remarkable doggers are well exposed in the railway cutting at Oakley Station on the main line from London to Leicester, where some of them measure 10 feet across and 30 feet in circumference. The doggers are merely locally indurated lumps of sandstone, and the outcrop of the bed gives a white tinge in dry weather to the fields on it, earning for them the name of 'The White Land' in the district.

7. *The Polyzoa of the Hunstanton Red Chalk. By* G. R. Vine.

In this paper the author gave a bibliographical notice including 25 references, and acknowledged the use of the collection in the Royal School of Mines. After referring to the apparent poverty of a polyzoan fauna in some cretaceous rocks, he proceeded to describe the polyzoa encrusting over a thousand specimens of fossils from the collection of Mr. T. Jesson, F.G.S. After some remarks on classification, figures and descriptions of 16 species belonging to the genera *Stomatopora* and *Proboscina*, were given.

MONDAY, SEPTEMBER 16.

The following Papers and Report were read:—

1. *The Devonian Rocks of Great Britain. By* W. A. E. Ussher, *F.G.S.*

The Devonian rocks of the south-west of England are divisible into three typical areas, viz. the northern area, including North Devon and West Somerset; the southern area, or South Devon; the western area, including Devon west of Dartmoor, and Cornwall. The characteristics of these regions may be summed up as follows:—

Northern area:—Prevalence of arenaceous deposits indicative of shoal water and proximity to coast, as pointed out by Dr. Kayser in a recent paper on the results of a trip to North and South Devon under the guidance of the author.

Southern area:—Great variability; volcanic eruptions sporadic from the Eifelian to the Fammenien and locally protracted (Ashprington volcanic series). Coral reefs seem to have grown irregularly upward over considerable areas contemporaneously with muddy sedimentation beyond their borders. Arenaceous deposits are confined to the Lower Devonian.

The Western area displays more uniform conditions, as muddy precipitation seems to have taken place almost uninterruptedly; arenaceous deposits, with some trivial exceptions, being confined to the lowest beds.

As regards structure, that of the Northern area is simple; but it is very different in the Southern and Western areas. Although cleavage and dip are often coincident in the slate districts, the frequent obliteration of planes of deposition justifies great caution in interpreting structure by divisional planes. The crushing and plication so manifest in the bedded limestones show us what to expect in the slate areas. The persistence of direction of dip, where reliable, affords by no means a

Franco-Belgian Classification			Devonshire: Northern Area	Devonshire: Southern Area	Devonshire: Western Area	German Classification	
Upper Devonian	Famennien, Slates and Psammites (Slates, four zones)	*Spirifer distans* *Rhynchonella letiensis*	Pilton Beds: Argillaceous slates with fossiliferous lenticles, often calcareous, and intercalated grits	Slates of Druid, near Ashburton, with *Rhynchonella letiensis*, *Spirifer Verneuili*, &c. Slates of Livaton, &c., near Bovey Tracey with *Clymenia* (?) *undulata* * — — — — — — — — —	Slates of West Litton with *Spirifer Urii* Slates of South Petherwin with calcareous lenticles (*Rhynchonella pleurodon*, *R. letiensis*, *Spirifer Verneuili*, &c.		Upper Devonian
		Rhynchonella Dumonti *Rhynchonella Omaliusi*	Baggy Beds: Sandstones with *Cucullaea* Slates with *Lingula*	Slates with calcareous nodules (*Clymenia laevigata*) local Red and green slates (Cypridinien Schiefer) (*Posidonia venusta*, *Entomis serrostriata*)	Greenish and grey slates with quartz, apparently unfossiliferous	Ludwig's Fucus Sandstone (?) Knollen-Kalk. Cypridinien-Schiefer.	
	Frasnien	Schistes à *Cardium palmatum* Calcaire avec *Rhynchonella cuboides*	Pickwell Down Beds: Indian red slates locally form the upper part; purple slates locally the lower. The series chiefly consists of red, green, and grey grits Morte Slates: Pale greenish quartz-veined, unfossiliferous	Red and grey slates with volcanic tuffs, &c. Red slates and Mudstones of Saltern Cove, *Goniatites*, *Cardium palmatum* Upper part of Chudleigh limestone, *Goniatites* Lower part of Chudleigh limestone, *Rh. cuboides*. Limestone masses of Ramsleigh, Petitor, Ilsham, and perhaps upper part of reef masses west of Kingskerswell *Below the broken line the Upper Devonian seems to be represented by unfossiliferous slates over a large part of the area.	Dark and pale grey slates with volcanic beds interstratified Pale grey slates passing downward into green and Indian-red slates; locally greenish as at Rame Head; locally Indian-red as at Devonport and Mutley	Goniatiten-Schichten and Adorfer-Kalk. Iberger-Kalk.	
Middle Devonian	Givetien	Calcaire de Givet	(Morte Slates) slates passing downwards into:— Ilfracombe Slates: Grey and silvery slates with lenticular limestone in places, developed on the Quantocks	Stringocephalus limestone in places continuous from base of Upper Devonian to the Calceola beds; but passing out into slates containing lenticles of distorted fossils, *Atrypa reticularis*, &c. Where the Ashprington volcanic series is developed this stage is often entirely represented by it	Dark grey shales or slates with beds and lenticles of limestone (*Heliolites porosa*). Calcareous shales with limestone beds, lenticular, locally over- and under-lain by buff sandstones and shales	Stringocephalen-Kalk.	Middle Devonian
	Eifelien	Schistes et Calcaire de Couvin	Combe Martin Slates: The lower part of the above contains intercalated grit beds (?) Also uppermost slaty part of the Hangman beds	Slates containing local developments of limestone as at Hope's Nose and near Totnes (with *Cyathophyllum helianthoides*, *C. damnoniense* and *Cystiphyllum vesiculosum*)	Yellowish and buff shales, and grey quartz-veined slates partly arenaceous	Calceola-Kalk. Calceola-Schiefer.	
Lower Devonian	Coblenzien	Grauwacke et Schistes rouges	Hangman grits. Grits and slates with *Natica* and *Myalina*	Dartmouth slates (probably).	Grey, green, and red slates with grit beds. The grits of Maker and Picklecombe Fort	Obere Coblenz-Stufe.	Lower Devonian
			Lynton beds. Even grits and calcareous slates, *Spirifer hystericus*, &c.	Cockington grits and slates and the Lincombe and Warberry grits and slates (*Pleurodictyum*, *Homalonotus*, *Spirifer cultrijugatus*, *Spirifer hystericus*)	Dark grey slates or shales and grey, buff, and red shales and gritty slates	Untere Coblenz-Stufe.	
	Gedinnien	Arkose	Foreland grits. Quartzose grits with slaty beds	Meadfoot Beds, dark slates with quartzose grit (*Pleurodictyum*, *Homalonotus armatus*, *Spirifer hystericus*, &c.	Looe beds, grits and slates (*Pleurodictyum*, &c.)	Siegener Grauwacke.	

sure indication of stratigraphical succession, as inversions with very sharp axes are prevalent, reversing the order of apparent superposition. Thrusts or reversed faults on a small scale have frequently resulted from the crushing, and as lithological horizons cannot be regarded as persistent, the difficulties encountered in deciphering the structure of these areas are at once apparent.

The table of classification on the preceding page shows the relations of the strata in the three areas, and their foreign equivalents. Although to a great extent merely provisional, especially as applied to Cornwall, it is hoped that this may afford a useful basis for further researches in the British Devonian rocks. The author expresses his grateful thanks to MM. Gosselet and Barrois for their identifications of fossils sent to the former from time to time.

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2. *Sketch of the Rise and Progress of the Cleveland and South Durham Salt Industry, and on the Extension of the Durham Coal-field.*[1] *By* Professor G. A. Lebour, *M.A., F.G.S., and* John Marley.

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3. *Fifteenth Report on the Circulation of Underground Waters.*

See Reports, p. 71.

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4. *On the Spinal Column of* Loxomma Allmanni, *Huxley, from the Northumberland Coal-field. By* D. Embleton, *M.D., F.R.C.P.*

Mr. Alderman Barkas, F.G.S., who presented the specimen now before the Section to the Museum of the Natural History Society of Northumberland and Durham in the year 1887, informed me that it had been discovered about seventeen years before by a miner, in the black shale of the roof of the Low-Main seam of coal at Newsham Colliery near Blyth, and brought to Newcastle to Mr. Barkas.

This fossil consists of a much longer series of vertebræ of the spinal column of *Loxomma Allmanni* than has hitherto been got from our coal-fields. It lies on its right side.

It is made up of two fragments of very unequal length; the longer is an uninterrupted series of thirty-two vertebræ, with their intervertebral discs, and a small portion of an anterior zygapophysis of another.

In connection with these vertebræ are several broken portions of ribs. This fragment measures 4 ft. 1½ in. in length.

The shorter fragment is only six inches long, and is separated from the longer by an artificial or arbitrary space, not at all that which in the complete spine would have existed between the parts.

The skull, an unknown number of vertebræ at each end of both fragments, the sternum, and by far the greater number of ribs (indeed there is no entire rib), the thoracic and pelvic girdles, and their limbs, are absent.

These two fragments are assumed to be the remains of an adult *Loxomma Allmanni*, for the bones closely resemble those which have been, on the authority of Huxley, declared, or acknowledged, to have belonged to that Labyrinthodont amphibian.

There is no evidence adducible to demonstrate that Loxomma was furnished with any defensive armour.

The bodies of the vertebræ are strongly made, longitudinally grooved, and have their anterior and posterior surfaces concave.

As to the vertebræ marked 1, 2, 3 on the specimen, it is difficult to say whether they are posterior cervical, or anterior dorsal; each has on its left side a small ovoid, concave, articular facet, it is therefore presumable that they are dorsal; if they are not, then the animal has had cervical ribs.

[1] This paper will be published in full in the *Transactions of the Federated Institution of Mining Engineers.*

Each of the next four has on its left side a distinct process, terminating in a concave ovoid surface for articulation with the head of a rib; each has also a broad, square, well-defined neurapophysis, and three pairs of their zygapophyses have retained their normal juxtaposition. There are four fragments of ribs lying on or near these vertebræ, and a slender tooth of Megalichthys lies on one of these fragments.

With the exception of No. 8, the next five vertebræ, with their intervertebral discs, are fairly well preserved, their neural spines fairly visible. All have costal facets. Three portions of ribs lie above, and four, from 4 to 6 inches long, below, this part of the column.

Nos. 13, 14, and 15 are less perfect than the above.

The next four have neural spines nearly entire, their bodies stout, and their zygapophyses in juxtaposition. They have facets for ribs, and below tnem are five portions of ribs broken off at the edge of the specimen.

Nos. 20, 21, 22, 23, and 24 are without processes. Five fragments of ribs lie under and near these.

From Nos. 24 to 30 the bodies diminish somewhat in size; below No. 25 is a flat piece of bone about 1½ inch across, suspected of some relationship with a possible pelvic girdle, and on this piece lies the head of the first of a series of peculiar costal bones, which belong to the right side of the spine, those of the left having disappeared. They are seven in number, and there is an indication of an eighth. Each appears double, like two ribs united for a certain distance by a smooth, rather concave plate, which ends in a concave edge; the lateral parts, in form of ribs, are continued separately beyond, that lying next the column being very much shorter than the other. Each ends above in a concave surface for articulation; in the first, fifth, sixth, and seventh the two parts appear pressed together, and as if they were articulated to contiguous parts of the intervertebral substance. The opinion of palæontologists as to these ribs is requested.

From No. 30 to the end of the larger fragment the two remaining vertebræ are much like those in front of them.

The smaller fragment of the column shows four vertebral bodies and discs, somewhat broken off on the upper surface. On each is a more or less distinct facet for articulation, either with ribs, or, if this fragment be caudal, for receiving chevron bones peculiar as adjuncts to caudal vertebræ.

It is difficult to estimate the length and bulk of such a creature.

It is much to be regretted that greater pains were not taken when it was discovered to secure the whole of the deposit.

The total length of the two fragments is 4 ft. 7½ in. The skull, if we can judge from skulls of Loxomma in our museum and elsewhere, was about 14 in. in length; if for absent vertebræ at each end of the large fragment we allow about 12 inches; for vertebræ at the posterior end of the smaller fragment, including the caudal appendage, six or even seven feet—the tails of modern amphibians, crocodiles and alligators, being fully as long as, or even longer than, the head and body together; and if we allow two inches for shrinking during the decomposition and fossilisation of the body, we make the total length of the animal during life to be about 14 feet.

Doubtless this great amphibian was an air-breathing, powerful, predaceous inhabitant of the muddy swamp or lake, possibly of warm water, that in remotely ancient time occupied the surface of the country, and which succeeded to the long series of ages during which the dense tropical vegetation flourished that was afterwards converted into that particular seam of coal now known as the Low-Main.

It swam like a fish or a newt, urged on by its powerful caudal propeller, and guided partially by its imperfect limbs, and may have been capable of getting on to dry land to bask in the sunshine.

This specimen, as well as the skull, various vertebræ, and other bones and teeth of Loxomma, with drawings of microscopic views of the last, are exhibited in the cases containing the Coal-measure Fossils in the Geological Department of the new museum of the Natural History Society in Newcastle.

5. *On the Bone Caves of Cresswell, and Discovery of an Extinct Pleiocene Feline* (Felis brevirostris) *new to Great Britain. By* Dr. R. Laing.

Cresswell Crags form a ravine in magnesian limestone of the Permian formation, a small brook running through it dividing the counties of Derby and Notts. They contain several caves, fissures, and rock shelters, which in the late Pleistocene age were alternately the abode of the spotted hyæna and man. The 'Pin Hole' was explored by the Rev. J. Magens Mello, in 1875, when he found remains of the grizzly bear, wolf, common fox, bison, reindeer, Irish elk, horse, woolly rhinoceros, mammoth, glutton, and Arctic fox, the latter being new to Britain. The Robin Hood and Church caves were next explored by Professor Boyd Dawkins and the Rev. J. M. Mello, assisted by a committee of geologists. The remains found were the same as those of the Pin Hole, with the addition of the lion, *Machairodus latidens*, leopard, and man.

I afterwards explored the Dog Hole; its contents being similar to those of the Pin Hole, with the addition of the wild boar. I then further explored the Robin Hood cave, and in the south-west corner an oval cairn twenty feet long of stones and earth was found, over a fissure twenty-one feet deep, which terminated in a cavern, both filled with unfossiliferous red sand. The Palæolithic beds crosssed over the top of the fissure. The cist was constructed of stone slabs of enormous size, sunk through the fossiliferous beds into the red sand. A *radius* and *humerus* were all that remained of the skeleton, which had apparently been in a crouching position. An elaborately-chipped flint spearhead appeared to belong to the interment. This interment simulated one of Palæolithic age, the two kinds of remains being together, and in nearly the same mineral condition, but was proved to be Neolithic, as the cairn sealed up the entrance to a deposit of Neolithic age, resting upon Palæolithic beds continuous with those of the front cave, in a horseshoe shaped gallery 120 feet long, which was filled with red sand. The north end of the gallery had not been invaded by the animals or man. The Pleistocene deposit was covered with six to eight inches of stalagmite. Remains of the historic period were rarely found in the front cave when originally explored; the following were, however, found in the gallery, and identified by Professor Boyd Dawkins:—Irish elk, stag, roe, goat, urus, horse, bear, badger, wolf, fox, wild cat, and hare. There were also human bones, and a flint spearhead of a Neolithic make. The Pleistocene deposit contained the same fauna as its continuation in the front cave, with the addition of *Felis brevirostris*, of which two mandibles, an upper *maxilla*, and a *radius* were found near each other beneath the stalagmite. It is an extinct feline new to Britain, not previously found in a bone cave, but described with remains from the upper Pleiocene in France. The original description is by MM. Croizet et Jobert, "Ossemens fossiles du Puy-de-Dôme," vol. i. p. 200. Two mandibles were found by them with others of another species, the *Felis issiodorensis* or Issoire cat.

The following is their summary of the distinguishing features of the mandible of *Felis brevirostris*:—

'La troisième incisive est beaucoup plus grande que dans toutes les espèces, et placée immédiatement contre le bord interne de la canine, c'est comme une seconde et plus petite canine. L'angle antérieur du bord inférieur est extrêmement prolongé, le trou mentonnier descend beaucoup en même temps de sorte que le prolongement du menton ne peut pas être l'effet d'un accident.'

The Cresswell specimen possesses these characteristics, the lower border being prolonged in a straight line, and ending in a tubercle which projects below the level of the jaw. The incisors are wanting, but enough is left of the alveolus to show the peculiarity mentioned by MM. Croizet et Jobert. The upper jaw is quite unique, having a molar series of only three teeth, the anterior premolar tubercular tooth being quite absent, with no trace of any alveolus, and the canine tooth is apparently enlarged in compensation. The anterior palatine foramen perforates the palate process further back than in existing cats. The extremely carnivorous nature of the animal is shown by the absence of the first tubercular tooth, the large size of the canine, and the small size of the tubercle and massiveness of the blade of the sectorial tooth in the upper jaw. In the lower jaw the canine is

rather smaller, but has pressed into its service the third incisor tooth as an auxiliary canine. We may infer from this that, if we could find an earlier evolution of the animal, the lower canine would be larger at the expense of the adjoining incisor tooth, as the upper canine is in respect of the premolar tooth.

The remains were determined by Professor C. Stewart, of the Hunterian Museum, College of Surgeons.

Dimensions of Mandible of Felis brevirostris, *in inches.*

Length of jaw	4·54
„ of molar series	1·52
Carnassial, length	0·64
„ posterior transverse diameter	0·265
„ anterior transverse diameter	0·27
„ height	0·365
Second premolar, length	0·50
„ transverse diameter	0·25
„ height	0·34
First premolar, length	0·39
„ transverse diameter	0·225
„ height	0·265
Depth of jaw at carnassial	0·83
„ „ premolar 2	0·855
„ „ premolar 1	0·89
Thickness of jaw at carnassial	0·41
„ „ premolar 2	0·41
„ „ premolar 1	0·40
Depth at symphysis	1·335
Breadth at symphysis	0·51
From canine to carnassial	1 29
„ to premolar 1	0·445
Interval between premolar 1 and 2	0·075
Antero-posterior diameter of canine at alveolar border	0·04
Transverse diameter of canine at alveolar border	0·03

Dimensions of Superior Maxilla (left) of Felis brevirostris.

Length of jaw	2·835
Posterior tubercular molar, length	0·27
„ thickness	0·14
„ depth	0·12
Carnassial, length	0·755
„ breadth	0·35
„ height	0·435
Premolar, length (internal)	0·49
„ thickness	0·26
„ depth	0·37
Third lateral incisor to premolar	1·05
Alveolus of canine to premolar	0·33
Antero-posterior diameter of alveolus of canine	0·455
From anterior border of jaw to anterior palatine foramen	0·56

Measurements of Radius.

Extreme length	6·72
Greatest diameter at distal extremity	1·30
Lesser diameter at distal extremity	0·68
Greater diameter proximal end	0·76
Lesser diameter proximal end	0·52
Least circumference of shaft	1·325

At the rear of the Robin Hood cave is a natural tunnel 18 feet long filled with red sand, which led into a cave 50 feet long, 30 feet broad, and 11 to 27 feet high, silted up to within a short distance of the roof. In a descending series this

consisted of unfossiliferous red sand continuous with that in the front cave, where it is the lowest bone-bearing bed; sandy clay, containing rolled pebbles; stiff red clay and yellow ferruginous sand, containing bones and teeth of *Hippopotamus major*, *Rhinoceros leptorhinus*, *Bison priscus*, *Cervus alces*, *Sus scrofa*, *Canis lupus*, *ursus*, *Hyæna crocuta*, *Arvicola amphibia*. These were determined by the Rev. J. M. Mello, F.G.S. No remains of burrowing animals were found in the cave. Hippopotamus and leptorhine rhinoceros had been previously found in similar deposits in the Grundy cave at Cresswell.

Occupation by man was shown by 'pot boilers,' charcoal, a charred canine of bear, chopped bones, with choppers and scrapers of the rudest Acheulien type. On the floor of the cave, beneath a great block of limestone, a fragment of skull was found, determined by Professor Boyd Dawkins to be human, and by the side of the stone a fragment of human fibula. These I saw taken out *in situ*. In the middle of the cave an artificial pillar of limestone blocks had been erected by the cave-dwellers to prevent the fall of a large stone from the roof. The cave had been closed up and undisturbed since the Pleistocene age. The light calcareous sand, containing limestone blocks and devoid of fossils, was found only in the lowest level shafts, and as the lowest bed of the largest caves and fissures, and was probably deposited as a débris of the rocks before the caves were opened into a ravine. But there is evidence of a later formation of a smaller set of caves, fissures, and shafts, during the deposition of the red sand. These contain no light-coloured sand, and were completely filled with unfossiliferous red sand and limestone blocks, crusted over with red stalagmite, coloured by the red silt left in the upper reaches of the shafts. The red sand being unfossiliferous, except only in the upper exposed layer in the Robin Hood cave and gallery, points to a long period of time between the occupation of the posterior, or Little John, cavern and the first occupation by the 'river-drift' men of the front, or Robin Hood, cave. And another long interval must have existed between these latter and the later cave-men, whose descendants are supposed to be the Eskimos. As these latter were in close relation with the ice sheet, the earliest occupation was probably interglacial. The zoological evidence points to the same lapse of time.

The latest Palæolithic or cave-men proper were probably evolved as a distinct race by the advance of the ice pressing the earlier 'river-drift' men into the territories of hostile tribes, with enforced residence near the ice sheet.

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6. *On the Fossil Fishes of the Devonian Rocks of Scaumenac Bay and Campbellton, Canada. By* Dr. R. H. Traquair, *F.R.S., F.G.S.*

The Edinburgh Museum of Science and Art having recently acquired a good collection of the fossil fishes from the Upper Devonian of Scaumenac Bay and the Lower Devonian of Campbellton, the author is enabled to give some notes supplementary to the descriptions of Mr. J. F. Whiteaves in the Transactions of the Royal Society of Canada. Dr. Traquair rectifies the descriptions, especially of *Phaneropleuron curtum*, Whit.; *Eusthenopteron Foordi*, Whit.; *Coccosteus acadicus*, Whit. As new species are described, *Cephalaspis Whiteavesii*, Traq.; *Gyracanthus incurvus*, Traq., while *Coccosteus acadicus* Whit., is erected into a new genus *Amblyaspis*.

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7. *On the Occurrence of the Devonian Ganoid* Onychodus *in Spitzbergen.*[1] *By* A. Smith Woodward, *F.G.S., F.Z.S.*

In the collection of Devonian fossils from Mimes Dal, Spitzbergen, in the State Museum, Stockholm, kindly shown to the author by Professor Lindström, is a small, arched, tooth-bearing bone, indistinguishable from the so-called 'intermandibular arch' or 'presymphysial bone' of the remarkable Ganoid fish, *Onychodus*. The genus has hitherto only been met with in the Devonian of Ohio and

[1] Printed *in extenso* in *Geol. Mag.* [3] vol. vi. 1889, p. 499.

New York (Newberry, 'Geol. Surv. Ohio,' vol. i., pt. ii., p. 296) and the Low. Old Red Sandstone Passage Beds of Ledbury, England (*Onychodus anglicus*, A. S. Woodw., 'Geol. Mag.' [3] vol. v., p. 500). The new specimen thus considerably extends the known range of *Onychodus* in space, and, so far as can be ascertained, pertains to a hitherto undetermined specific type. Four fractured teeth are preserved, scarcely more than half as large as those of the smallest described species, *O. anglicus*, and differing from the latter in the very large size of the internal cavity. The form may be provisionally named *Onychodus arcticus*.

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8. *Notes on some new and little-known British Jurassic Fishes.*[1] *By* A. Smith Woodward, *F.G.S., F.Z.S.*

The remains of many undescribed fossil fishes from British Jurassic formations are preserved in various collections, and the author remarks upon a few of the more prominent types. Some are of genera already recognised on the Continent, but not hitherto discovered in England.

1. *Eurycormus grandis*, sp. nov. Founded on a well-preserved head from the Kimmeridge Clay of Ely, in the Woodwardian Museum. About twice as large as the typical *E. speciosus*, and differing in the granulation of the head-bones.

2. *Strobilodus suchoides*, Owen sp. As suggested by Von Zittel, the so-called *Thlattodus suchoides*, Owen, from the Kimmeridge Clay of West Norfolk, is certainly generically identical with the previously described *Strobilodus giganteus* from the Bavarian Lithographic Stone.

3. *Hypsocormus Leedsi*, sp. nov., and *Hypsocormus tenuirostris*, sp. nov. The jaws of two new species of *Hypsocormus* have been discovered in the Oxford Clay of Peterborough, by Mr. Alfred N. Leeds, of Eyebury. The first (*H. Leedsi*), equals the Bavarian species, *H. macrodon*, in size, and has a similarly obtuse snout; but it differs in the marked obliquity of the two great teeth in the upper jaw. The second species (*H. tenuirostris*) attains about half the size of the first, and is distinguished by the comparative elongation and acutely pointed form of the snout; the two great upper teeth seem to have been directed almost vertically downwards, as in *H. macrodon*. These fossils suggest an interesting comparison between the dentition of *Hypsocormus* and that of the Upper Cretaceous *Protosphyræna*; two large tusk-like teeth at the base of the snout in each genus being opposed to a pair of similar teeth on each side of the mandible, fixed in sockets in a short, stout, splenial bone.

4. *Leedsichthys problematicus*, gen. et sp. nov. This, probably the largest Jurassic fish hitherto discovered, is indicated by an associated series of bones from the Oxford Clay of Peterborough in Mr. Leeds' collection. It can only be provisionally defined, and may be appropriately named *Leedsichthys problematicus*. None of the bones are externally ornamented, but all have a distinctly fibrous texture. A supposed frontal bone measures 2 feet in length by 1 foot 3 inches in maximum breadth; the hyomandibular is squamous, at least 1 foot 3 inches in length; and the bones of the branchial arches are irregularly <-shaped in transverse section, bearing numerous gill-rakers. The last-named bones are elongated, laterally compressed, slightly expanded at the base, and rarely straight, but irregularly bent and contorted; the surface is coarse and rugose, and one long border is rounded while the other is cleft by a longitudinal median furrow; the rounded border is comparatively smooth, but the furrowed edge is coarsely serrated, a series of short oblique ridges terminating in points on each side. The branchiostegal rays are very large, dense, and rounded in section, in not less than six pairs. The pectoral fin-rays sometimes attain a length of 5 feet, frequently dichotomously branching, but not jointed; each consists of fibrous bone, appearing as if composed of numerous long, tapering splints incompletely fused together, and the two halves of the ray remain separate. The jaws and axial skeleton of the trunk are still unknown.

5. *Thrissops*. Though not hitherto recorded, remains of the genus *Thrissops*

[1] Printed *in extenso* in *Geol. Mag.* [3] vol. vi. 1889, pp. 448–455.

are preserved in the British Museum from the Kimmeridge Clay and Portland Stone of Dorsetshire; the former equal *T. Heckeli*, Thiollière, from the French lithographic stone, in size; the latter are much smaller.

6. *Browneichthys ornatus*, gen. et sp. nov. Remains of a small elongated fish discovered by Mr. Montagu Browne in the Low. Lias of Barrow-on-Soar, pertain to a new generic and specific type, apparently related to the Belonorhynchidæ. The notochord is persistent and the neural and hæmal arches are ossified, but there are no well-developed ribs. The scales are thin, cycloidal, with prominent concentric lines of growth, deeply overlapping and externally ornamented with ganoine tubercles. Portions of a dorsal and ventral series of very large, narrow, pointed ridge-scales are also observable. The cranial bones are invested with ganoine, and are coarsely tuberculated.

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9. *On the Relations between the Geological Constitution and the Magnetic State of the British Isles.* By Professors A. W. RÜCKER, *F.R.S.*, and T. E. THORPE, *F.R.S.*

During the last five summers the authors have determined the magnetic elements at two hundred stations, distributed over the whole of the United Kingdom, and have employed the results of their observations in a study of the disturbing magnetic forces which are in play in various districts.

It is generally known that the magnet does not point due north, and that the declination or deviation from true geographical north is different in different parts of the world. At London it is about 18° W., and is greater at stations which are either to the north or west of the metropolis.

Thus, if all disturbing causes were removed, an observer travelling due west from London would find that the declination increased by about half a degree for each degree of longitude. As a matter of fact the rate of increase, though equal on the average to this amount, is irregular. Between London and Windsor it is considerably larger, between Windsor and Reading smaller, than the mean. The forces which produce these abnormal variations depend upon the geological character of the district. They may be called *local* or *regional disturbing forces*, according as they influence small or large areas.

The authors have calculated the direction and magnitude of these forces at all the stations included in their survey, and have found that it is possible to divide the British Isles into a comparatively small number of districts, in each of which the disturbing forces tend towards certain definite points or lines.

Two principal theories have been proposed to account for such phenomena. Many igneous rocks, and notably basalt, contain magnetic oxide of iron, and the deviations of the needle may be explained by the presence of such rocks, either visible upon the surface or concealed beneath it. The other explanation associates the deflections of the needle with disturbances of the earth currents of electricity, produced by irregularities in the geological constitution of the country, and especially by geological faults.

In attempting to decide between these the authors point out (1) that even igneous rocks, which are very feebly magnetic when tested in the laboratory, produce in large masses very considerable effects upon the magnet. Thus the Malvern Hills, though composed of diorite in which magnetic polarity can barely be detected, produce deviations of twenty minutes of arc at a distance of a mile from their axis. (2) Mr. Preece, F.R.S., chief of the Telegraph Engineering Department of the Post Office, most kindly caused measurements of the earth currents to be made in two districts in which the authors had discovered large deviations of the magnet. In the neighbourhood of Melton Mowbray it was found that the largest difference of potential per mile was about forty times less than that which accompanies a similar deviation of the magnet at Greenwich during a magnetic storm. In the neighbourhood of Reading and Windsor, though the local deviations of the needle are such as only occur in very violent storms, no measurable earth currents were detected. These observations are therefore inconsistent with a view which postulates surface earth currents as the cause of the

disturbances. (3) If the effective earth currents are supposed to be deeply seated within the earth—possibly in strata of higher conductivity—it becomes more difficult to account for the local character of the magnetic disturbances. (4) The authors' observations prove that the disturbing forces tend towards points and lines, and if earth currents produce them they must circulate round the districts thus indicated. It is difficult to suggest a physical cause which would produce such an effect. (5) On the other hand, the authors found that in several cases the centres or lines of attraction are closely connected with the presence of magnetic rocks, and especially with basalt. The Western Isles of Scotland, the coalfield in South Scotland, the north of Ireland, and Mid-Wales and Shropshire all present centres of attraction, and are all marked by the presence of large quantities of basalt.

In two cases where loci of attraction are not connected with visible igneous rocks they nevertheless occur in places where there is reason to believe that the older rocks approach near to the surface. This is the case in south-east Yorkshire, and along a line which runs from London to South Wales, and possibly to Wexford, which agrees in general direction with the Palæozoic ridge which connects the coalfields of South Wales and Belgium.

On the whole, then, the authors think that the theory of the direct action of magnetic rocks agrees best with the observed facts; and they show that the kingdom can be divided into a small number of magnetic districts, in which the directions of the disturbing forces are evidently closely connected with their geological constitution.

The authors have prepared, with the kind help of Professor Judd, F.R.S., a map, which shows the main geological features of the country, and also the main lines toward which the disturbing magnetic forces act. The latter are closely associated with the following geological features: (1) the fault line of the Caledonian Canal; (2) the basalt of the Western Isles of Scotland; (3) the basalt of the coalfield in the south of Scotland; (4) the region in south-east Yorkshire in which the Jurassic strata thin out; (5) the basalt in Mid-Wales and Shropshire; (6) the line of the Palæozoic ridge; (7) the basalt of Antrim; (8) the igneous rocks of Connemara.

All the principal masses of basalt in the kingdom thus form centres of magnetic attraction, and two lines of attraction (in Yorkshire and the south of England) occur in places in which the older rocks are supposed by geologists to approach the surface. In one or two cases, and notably near Kells in Ireland, a well-marked magnetic centre of attraction occurs in a place where no known geological feature serves to account for it. On the whole, however, the connection between visible basaltic masses and loci of magnetic attraction is so marked that it can hardly be doubted that elsewhere magnetic attractions indicate the presence of concealed igneous rocks, and afford a means of approximately tracing their distribution relatively to the surface sedimentary deposits by which they are concealed.

TUESDAY, SEPTEMBER 17.

The following Papers and Reports were read:—

1. *Notes on the Geology of Torres Straits.* *By* Professor A. C. Haddon, *M.A.*, *M.R.I.A.*

After having examined a number of the islands in Torres Straits, I can fully confirm the triple division of the islands made by Jukes. The lines of longitude 142° 48′ E. and 143° 30′ E. conveniently demarcate these subdivisions.

The islands to the west are all composed of old igneous rocks and are surrounded by fringing reefs. The central group is composed of low coral islets formed by wind and wave action. The eastern islands Uga, Erub, and the Murray Islands, are of volcanic origin, and are also fringed with coral reefs. There are numerous large and small coral reefs in the Straits, but no atols.

I have satisfied myself that Torres Straits is not an area of recent elevation, no traces of raised beaches or of elevated coral formations were observed. The coral beach-rock on Nagir, recorded by Macgillivray, can, I believe, be accounted for without invoking an elevation hypothesis. Depression of land is less easy to demonstrate than elevation, but of this also no evidence could be found.

Of the volcanic islands, Mer, the largest of the Murray group, was most carefully studied. Part of the circumference of this island is composed of inclined beds of stratified volcanic ash with a quâquâversal outward dip. In the centre of the island is an old cone. The northerly portion of Mer is mainly a lava stream. Here, again, there are no raised shore or deep-sea deposits.

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2. *Report on an Ancient Sea-beach near Bridlington Quay.*
See Reports, p. 70.

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3. *Seventeenth Report on the Erratic Blocks of England, Wales, and Ireland.*—See Reports, p. 115.

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4. *On a Deep Channel of Drift in the Valley of the Cam, Essex.*
By W. WHITAKER, *B.A., F.R.S., F.G.S., Assoc.Inst.C.E.*

Well-sections have given us much information as to the deep-seated geology of the London Basin and of the rising up of older wells beneath the Cretaceous beds. We have now like evidence of an occurrence of the opposite kind, the deep sinking down of Drift beds.

In Scotland and in northern England long and deep channels filled with Drift have been noticed, but not in southern England. There are, however, evidences of some such occurrences in Western Norfolk, though not to the depth of the channel now in question.

For some years one deep well-section has been known which showed a most unexpected thickness of Glacial Drift in the higher part of the valley of the Cam, where that Drift occurs mostly on the higher grounds and is of no very great thickness. Lately further evidence has come to hand, showing that the occurrence in question is not confined to one spot, but extends for some miles. Details of this evidence have beeen given in the 'Essex Naturalist,' (vol. iii. pp. 49–54), but the general conclusions are of more than local interest. The beds found are for the most part loamy or clayey.

At the head of the valley various wells at Quendon and Rickling show irregularities in the thickness of the Drift, the Chalk coming to or near the surface in some places, whilst it is nearly 100 feet to it sometimes.

Further north, at Newport, we have the greatest thickness of Drift hitherto recorded in the South of England, and then without reaching the base. At one spot a well reached the Chalk at 75 feet, whilst about 150 feet off that rock crops out, showing a slope of the chalk-surface of 1 in 2. The most interesting of all the wells is at the Grammar School, where, after boring to the depth of 340 feet, the work was abandoned without reaching the Chalk, the Drift in this case reaching to a depth of about 140 feet below the level of the sea, though the place is far inland. The Chalk crops out about 100 feet eastward and at but little lower level, so that there is a fall of about 1 in 3 over a long distance.

At and near Wenden the abrupt way in which Drift comes on against Chalk has been seen in open sections. Two wells have shown a thickness of 210 and of 296 feet of Drift respectively, and as the Chalk comes to the surface, at a level certainly not lower, only 140 yards from the latter, the chalk-surface must have a slope of 1 in less than $1\frac{1}{2}$, and this surface must rise again on the other side as the Chalk again crops out. The Drift here reaches to a depth of 60 or 70 feet below the sea-level.

At Littlebury, still further north, many wells have reached the Chalk at slight

depths, in some cases next beneath the soil, in others through a little River Drift (gravel); but in the centre of the village a boring 218 feet deep has not pierced through the Drift, which reaches to 60 feet below the sea-level. As in a well only 60 yards west and slightly higher the Chalk was touched at 6 feet there must here be a fall of the chalk-surface of about 1·2 in 1. Eastward too, on the other side of the valley, the Chalk rises to the surface.

It is noteworthy that in this last case the Geological Survey Map (Sheet 47) shows no Glacial Drift, and rightly so, for in no place does that formation come to the surface, being wholly hidden under narrow spreads of Alluvium and of River Gravel, together only about a quarter of a mile broad at the site of the boring. Without the deep well-sections therefore the presence of the Glacial Drift would not have been known.

The places that have been mentioned range over a distance of 6 miles. How much further the Drift-channel may go we know not, neither can we say to what thickness the slope of the underground chalk-surface may reach; the slopes given in each case are the lowest possible.

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5. *A Criticism of the extreme Glacial Views of Agassiz and his Scholars.* *By* HENRY H. HOWORTH, *M.P., F.S.A.*

In this paper the author rapidly traced the history of the so-called Glacial theory, from the time when ice was first invoked to explain the drift phenomena.

He discriminated between the earlier phases of the theory, as developed and taught by Charpentier and Murchison, which explained the facts by postulating a large development of local glaciers in former times, and with which he was in complete agreement, and the second phase of the theory, which he described as a glacial nightmare, which was developed by Agassiz and his scholars, and is still generally held and taught, and which appealed to an ice cap or ice sheet covering the polar area and extending far down into temperate latitudes.

The latter theory had been pressed by Agassiz until he found traces of his ice sheet in the tropics, and even filled the valley of the Amazons with ice.

Among the followers of Agassiz Dr. Croll has produced the only theory which is current to explain the possibility and nature of such ice caps. He argues for a combined astronomical and meteorological cause, by which each hemisphere has been alternately glaciated and subjected to temperate conditions, and argues that this alternation marked the geological calendar in all time.

In opposition to Agassiz's theory of an ice cap the author urged:—

I. The fact that the glacial phenomena only occur over one-half the lands surrounding the North Pole, which in this respect may be divided into two semi-circular areas by a line joining the mouth of the Mackenzie river with the eastern shores of the White Sea. They are quite absent in all the district stretching from the White Sea across Asia, over Behring Straits, throughout Alaska, and as far as the River Mackenzie. This remarkable fact is fatal to an ice-cap theory, which presupposes continuous conditions round the pole.

II. The evidence of Haast, Hector, McCoy, and the other explorers in New Zealand and Australia is unanimous that nothing corresponding to the drift phenomena of the northern hemisphere occurs there, and that there is therefore no evidence of such a condition of things as must have existed in the northern hemisphere; consequently, no evidence of the phenomena upon which an ice cap has been formulated in these latitudes; but, as the ice-cap theory necessitates a southern glaciation occurring alternately with a northern one, this position again is fatal to the postulate of polar ice sheets.

III. The unanimous testimony of explorers in the southern hemisphere concurs, again, in the conclusion that the great development of glaciers which took place in New Zealand and other places in the southern hemisphere was concurrent and contemporaneous with the similar development in the northern hemisphere, and did not alternate with it as required by the theory of alternating climates. Upon this point Agassiz's views were very pronounced in support of the contention of the author.

IV. While the phenomena of the drift are proverbially ubiquitous in those latitudes where they occur, and the evidence they furnish in the shape of boulders, smoothed rocks, and beds of unstratified materials is virtually indestructible, we may search all the older rocks in vain for corresponding evidence, and, except a few sporadic and most uncertain boulders found by Ramsay and Godwin Austen in the Permian beds, and some similar and very local traces in the Miocene beds, there is no evidence, either in the succession of life or in the lithology of the strata, to justify the theory. In regard to the succession of life Lyell wrote very emphatically that it afforded no evidence of interglacial periods.

V. The evidence of interglacial periods chiefly relied upon by believers in them is derived from the glacial beds themselves, the most difficult and heterogeneous in structure of all geological horizons, where traces of violent action abound, and where it seems impossible to find a key which shall explain the true succession even for two adjoining counties, much less for two large geographical areas, and the phenomena generally quoted can be better explained by other causes.

The evidence of the fauna and flora in the quaternary beds is also completely at issue with such a theory. Instead of alternating climates, nothing is more plainly proved than that the hyæna fed upon, and was therefore contemporaneous with, the reindeer in the same area: while the leaves of the grey willow are found mixed with those of the Canary laurel and the fig—pointing, not to a succession of alternate warm and cold climates, but to neutral conditions, where the life characteristic of different climates might live together.

VI. Such ice sheets as are required by the current theory to explain the existence of Scandinavian erratics in Southern Poland and Central Russia would cover the mountain tops in Norway, and cover therefore the very source of erratics.

VII. The movement of ice sheets over hundreds of miles of level plains without any *vis a tergo* has never been shown to be even possible and, so far as we can see, is inconsistent with the physical qualities of ice as now known.

For these, among other reasons, the author contended that the theory of ice sheets and of interglacial periods cannot be maintained; and although it is quite true that the facts require us to supplement the former existence of great glaciers by the operation of some other force if we are to explain the occurrence of drift, in many cases overlying old river channels and mammoth beds, and the existence of drift far beyond the reach of any possible glaciers, it is inconsequent and unscientific to appeal to a cause which is inconsistent with empirical tests and involves an appeal to forces unknown in Nature.

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6. *Note on a New Locality for the Arctic Shell-beds of the Basement Boulder Clay on the Yorkshire Coast. By* G. W. LAMPLUGH.

The basement boulder clay at the 'South Sea Landing' on Flamborough Head includes many irregular masses of fine gravel, silt, and sand, and one of these, a thin lenticular streak of greenish-yellow sand, contains many shells, though the neighbouring inclusions are unfossiliferous.

The matrix of these shells resembles some of the sandy patches which have yielded the Arctic fauna at Bridlington and at Dunlington. The shells obtained are also of the same species; so that there is every reason for believing that the bed is another fragment of the same sea-bottom, transported by ice, as in the previously known examples.

The species identified are as follows:—

Turritella erosa, Conth.
Natica affinis, Gmel.
Admete viridula, Fabr.
Dentalium entalis, L.
Pecten islandicus, Müll.
Leda (limalula?), Say.
Cyprina islandica, L.
Astarte sulcata var. elliptica, Da. Cos.
„ *borealis* and *vars.* Ch.
„ *compressa* and *vars.* Mont.
Mya truncata, L.
„ „ *var. Uddevallensis.*
Saxicava rugosa, L.
Balanus, Sp.

The seam containing the shells is only about 24 feet long, and is nowhere more

than 4 inches thick, and it has been dragged out at both ends into a mere thread in the boulder clay. Nevertheless, some of the shells are quite perfect, and the Astartes (by far the commonest forms) frequently occur with valves united. In other cases the valves have been trailed apart by shearing, but remain without fracture; while, still more frequently, the shells have been crushed into fragments and drawn out into a white streak.

In the previously-known localities the rare exposures of these shelly patches have taken place either in the cliff-foot or on the foreshore, so that, even when visible, it has only been possible to study the upper portion of the deposit which contained them. At the South Sea Landing, however, the shelly bed occurs in a cliff about 100 feet high, which shows the whole of the drifts overlying 30 to 40 feet of chalk. In this section stratified beds of sand and gravel are revealed both above and below the boulder clay which contains the shelly patch, but in neither position do these beds show any evidence of a contemporaneous fauna. We thus learn, what was before suspected, that these shell-bearing masses have not been derived from the destruction of beds pre-existing in their immediate vicinity, but are truly transported boulders.

The section is also valuable as placing beyond doubt the extension of the basement boulder clay of Holderness over Flamborough Head.

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7. *Did the Great Rivers of Siberia flow Southwards and not Northwards in the Mammoth Age?* *By* HENRY H. HOWORTH, *M.P.*, *F.S.A.*

During the mammoth age the mammalian fauna of the Palæ-arctic and Ne-artic regions was very nearly homogeneous. The remains of the mammoth, the bison, the elk, the horse, the red-deer, &c., are indistinguishable, whether found in Northern Asia or in North America.

This fact makes it clear, as the author has ventured to urge in the 'Geological Magazine,' that at that time there was a land communication between the two areas, and, as he has also attempted to show, this communication must have been across the Arctic area, which in the mammoth period was occupied by dry land, when comparatively mild conditions prevailed. This is also necessitated by the fact of finding numerous remains of the great mammals unweathered, and doubtless where the animals died, in the Liachof Archipelago, the Bear Islands, &c., some of them at least 200 miles from the mainland.

If the polar area was converted into dry land it would mean the elevation of the floor of the eastern part of the Arctic Sea to the extent of from 25 to 40 fathoms only, no greater depth having been met with there in the numerous soundings recorded from the time of Belcher to those made by the *Jeannette* expedition.

The Siberian rivers have notoriously a very slight fall, and, as has been said, there are points where they seem in doubt as to whether they should flow one way or the other. A series of careful levellings has been made by the Russians, and published by Petermann, which shows that a rise of from 25 to 40 fathoms at the mouth of at least two of these rivers—namely, the Yenisei and the Obi—would reverse their drainage, and make them flow southwards instead of northwards.

If we turn elsewhere we have a continuous chain of facts showing that, in the latest geological age, there was a Mediterranean Sea in Central Asia, of which the Caspian, the Seas of Aral and Balkhash, and the innumerable small lakes scattered over the so-called Kirghis steppes are the débris. The fact that they are what the Germans call Reliktenseen is shown by their fauna, and is generally accepted. Besides these, we have the evidence of great stretches of sand, strewn with marine shells in a semi-fossil condition, which intervene between the lakes.

These facts have combined to make a former Central Asiatic sea a postulate of elementary geography, but hitherto there has been no theory forthcoming to explain it. The reversal of the Siberian rivers would create and maintain such a sea; and the evidence is therefore bilateral and very strong that in the mammoth age the drainage of the greater part of Siberia was reversed.

It is curious that European Russia, which in other respects is a mere continua-

tion of Siberia, has a general slope which is southwards, causing its great rivers, the Ural, Volga, Don, &c., to flow southwards still; thus affording a sample by which to test the former condition of the great region stretching from the Carpathians and the Baltic to Behring Straits.

The effects of this change of physical feature must obviously have been manifold. The existence of a great Central Asiatic sea would greatly temper the Siberian climate, while the southern flow of its rivers would affect the distribution of animal and vegetable life, and offers at least a reasonable solution of the difficulties surrounding the migration of birds in the Palæ-arctic region, while it sweeps away the hypothesis that the mammoth remains of Siberia are the wreckage of river portage.

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8. *On the Witwatersrand Goldfields.*

By EDWARD BATES DORSEY, *Mem.Am.Soc.C.E.*, *Mem.Am.Inst.M.E.*

In the early part of this year the author visited South Africa on business connected with railways and mining, which made it necessary for him to examine critically into the mining capabilities of the southern portion of the Transvaal, which section is called promiscuously the Rand, Witwatersrand, or the Johannesburg district. The mines there are more developed than those in any other part of the State. The following is a brief description of the principal features of this district. As yet there has been no scientific or systematic study of the geology of this district; all that is known of it has been discovered or developed by the workings of the mines or in the search after gold-bearing veins.

The geological formation consists of a series of strata of sandstone, quartzite, slate, and conglomerate, all evidently deposited quietly by water. Part of the northern and eastern edge of this basin has been tilted up to an angle of 25 to 45 degrees from the horizontal by the irruption of diorite, and it is probable that the remaining portions of the vein will be found also tilted up, forming a basin over 100 miles long east and west, and 40 miles wide north and south. The dip on the northern edge is to the south, and on the eastern edge to the west. Johannesburg is on the extreme northern edge of this basin.

The formation is similar to that of coal, and will no doubt be found as regular as that of most coal basins.

An inferior quality of coal is found in workable quantities within 200 yards of workings on the Main Reef which produce good gold ore; and it is very likely that ore containing gold, and coal for fuel to crush it, will yet come from the same shaft.

As yet no fossils have been discovered from which the geological age of this formation can be ascertained.

The gold is contained in the conglomerate strata in quantities which vary from a trace to 8 ounces per ton. There have been a large number of these strata discovered, and probably many more will be found as work progresses. These strata vary in width from a few inches to many feet, but each one when compared to itself is very uniform in its yield of gold and in thickness.

In some few places the formation has been broken by the irruption of diorite, but not to the extent that could be expected when the size of the basin is considered.

These conglomerate veins are called locally ‘banket reefs’; in this paper they will be called ‘veins,’ being merely interstratified beds or veins. They are composed mostly of quartz, quartzite, and sandstone pebbles, varying in size from an inch in diameter down, though sometimes larger, the cementing matrix being composed of oxide of iron, sand, and some clay. This cement is generally soft, but in some cases it is so hard that when the ore is broken the quartz pebbles will break before the cementing matrix. As a rule the pebbles contain no gold. The gold is fine, with sharp angles, not at all waterworn, and showing no signs of being alluvial.

The Main Reef veins are among the lowest or deepest veins, and the Black Reef and Zuur-Bult Reef are the top or uppermost veins of this basin. As the Black Reef is very flat, with its north and south outcrop well defined, the Main Reef in depth will probably follow the same course, as all were undoubtedly deposited in

parallel strata. As work progresses in depth on the Main Reef it will be found to flatten, or have a decreasing dip from the horizontal, and then to become horizontal, and perhaps rising to the surface, thus forming the southern rim of the basin.

As yet no developments have been made to indicate the vertical distance between the Main and Black Reefs. Many intermediate veins have been found between these two; some of them can be worked profitably. The first work in this district was done on the Main Reef, and consequently it is more developed than the others. It has been very thoroughly worked and prospected for 30 miles in length, and fairly prospected for 60 miles more. With exceptions of a few faults (forming a very small percentage of the whole length), the present development in uniform and continuous pay *is over 25 miles long, with every prospect of being found to be much longer.*

The so-called Main Reef is composed of four parallel veins within workable distance of each other, aggregating about 15 feet in thickness, the Main Reef being about half of this; the average yield in gold varying from 8 pennyweights in the Main Reef to 8 ounces in the Robinson leader to the ton. The monthly variation in the average yield per ton in the crushings reported by individual mines is caused by varying the proportions of ore from the different veins. A larger amount from the rich leaders will cause a higher average, or a larger amount from the Main Reef will cause a lower average. The variation in the monthly yield is not caused, as many suppose, by change in the yield of the vein: each vein is fairly uniform when compared to itself. The Main Reef veins have been worked for 25 miles in length and to a depth of over 200 feet, and, with some few exceptions, have been found uniform in size and yield. At present there are about 800 stamps crushing ore from the Main Reef mines, crushing about 40,000 tons, and yielding about 30,000 ounces of gold monthly, which gives an average yield of three-quarters of an ounce of gold per ton of ore; this can be taken as the present average yield of the Main Reef, which will probably be largely increased as improved appliances for saving the gold and better management are adopted.

Owing to bad mining and milling in many mines (though some are very well managed), the present average expense of mining and milling is probably 30*s.* per ton. Estimating the gold at its market value of 3*l.* 10*s.* per ounce, this gives:—

	£	*s.*	*d.*
Average yield of ore per ton	2	12	6
Less estimated expenses as now worked . . .	1	10	0
Net profit per ton at present	1	2	6

This profit will probably be increased to 2*l.* by saving more gold and economies in the working cost, resulting from better arrangement.

These figures make the present value of each acre of ground underlaid by the Main Reef at an angle of 25 degrees, worth over 45,000*l.* net profit, with a strong probability of being soon doubled, as better work is done in mining and milling; this amount will also increase with the dip of the vein, in consequence of increasing the tonnage per acre.

The Black Reef vein is being worked in many places, and has been traced for a great many miles. It averages 3 feet thick, and yields in the 'Black Reef' mill 16 pennyweights of gold per ton. The total cost of mining and milling this ore is less than 20*s.* per ton.

The Zuur-Bult vein averages 3½ feet thick, and yields 1 ounce of gold per ton, at a total cost of mining and milling of less than 20*s.* per ton. These two last veins are the top or upper veins of the basin; as they lie very flat and level, and can be very cheaply worked, they promise to be important gold-producers in the future.

The richness of the mines of this district will be seen by comparing them with other mines. For example, take the Alaska Mining and Milling Company's mine, at present the best dividend-paying gold-mine in the United States. The following is the working for the six months ending June 15, 1889:—

108,000 tons crushed; average yield per ton	$3.80
Average cost per ton of mining and milling . . .	$1.89
Average net profit per ton	$1.91

This shows that ore yielding only about 4 pennyweights of gold to the ton leaves a net profit of one half of the gross yield.

The mining laws of the Transvaal will not allow the miner to follow his vein outside of his vertical lines. As the veins are more or less flat, the purchasers or owners of mines should ascertain the extent of vein in the claims from the outcrop or the point at which it enters until it leaves the claim by the side lines. This is a very important factor in determining the value of the mines in this district, and has heretofore been overlooked by purchasers.

As yet nothing has been developed to indicate the depth to which the gold will be found in paying quantities. The present developed pay on the Main Reef has been proved by actual work to be at least 30 miles long, with a very uniform yield of gold and ore. It hardly seems possible that it will not be found to extend down to a great depth. *All indications so far developed are that it will.*

The celebrated Comstock mine of Nevada, United States, might well be called a gold-mine, as the value of the bullion was and is about half gold. The richest body of ore found there was at 1,500 feet vertical depth; this deposit paid monthly dividends of 432,000*l.* for several years.

There have been a great many profitable deep gold-mines worked in the United States and Australia, many being still in good pay.

For several months past about 800 stamps have been crushing ore in this district; by the first of the year there will be probably more than double this number. Say, 2,000 stamps will be at work, crushing 4,000 tons of ore and producing 3,000 ounces of gold daily, or 75,000 ounces per month. This number will have to be very largely increased in order to crush in any reasonable time the ore already developed in the Main Reef veins, to say nothing of those required to work the ore from the Black Reef, Zuur-Bult, Chimes, Botha, and other veins, that have been proved already and profitably worked.

In 1887 South Africa produced 2 per cent. of the total annual product of the gold of the world—the author estimates that this year it will produce 7 per cent., and next year over 15 per cent.; this last amount will be increased proportionately with the increase of additional machinery.

This large increase in the annual production of gold may change the comparative value between gold and silver, unless there be a corresponding increase in the production of silver. Gold, probably, will depreciate and silver appreciate in their comparative values.

The author is aware that he is exposing himself to criticism by applying the word 'basin' to a goldfield, and estimating the yield of gold by the acre—in fact, he criticised reports made in this manner before he visited this district; but after examining it, and seeing how uniform the yield and thickness of the veins were, and how closely they resembled coal formations, he decided that they should be estimated by the acre the same as coal.

The author has examined closely all the principal gold and silver districts of North and South America, but in no case has he seen anything approaching this district in extent and uniformity of yield in ore and metal; veins with almost continuous and uniform pay for 25 miles in length being heretofore unknown in mining.

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9. *Third Report on the 'Manure' Gravels of Wexford.*

See Reports, p. 92.

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10. *On Barium Sulphate in Water-box Deposits from the Durham Coal-mine Waters and in Nottingham Sandstone. By* Professor FRANK CLOWES, *D.Sc.*

At the Aberdeen meeting of the British Association I communicated a preliminary notice of the occurrence at Bramcote, in the neighbourhood of Nottingham, of red sandstone, the grains of which were found to be cemented together by barium

sulphate.[1] This sandstone occurred over a considerable area, and formed the Bramcote and Stapleford Hills, as well as the pillar of rock known as the Hemlock Stone. The occurrence of this insoluble cementing material was held to account for the resistance to denudation which had given rise to the above-mentioned prominences. Since communicating the above paper, full quantitative analyses of specimens of this sandstone have been made, with the following results:—

—	Hemlock Stone		Stapleford Hill		Bramcote Hill	
	Top 1	Near base 2	Top 3	Base 4	'Pebbles' at top 5	Middle Height 6
Loss at 100° C. (moisture)	0·21	0·24	0·11	0·20	0·18	0·05
Loss by ignition (organic matter, &c.)	0·87	2·13	0·36	0·39	0·93	0·72
$Fe_2O_3 + Al_2O_3$	6·41	4·84	3·53	4·46	5·10	4·45
BaO	30·23	21·89	30·81	32·80	18·52	33·30
CaO	—	1·68	0·02	—	—	—
MgO	0·13	1·08	0·10	—	—	—
SO_3	16·39	12·09	16·58	17·14	10·14	17·42
SiO_2	44·46	54·52	47·36	43·77	62·59	41·47
Alkalis, &c. (by difference)	1·30	1·53	1·13	1·24	2·54	2·59
$BaSO_4$ present . .	46·03	33·33	46·92	49·95	28·20	50·06

A further examination made to ascertain the loss which the finely-powdered sandstone suffered when heated with dilute hydrochloric acid gave the following results:—

—	No. 1	No. 2
Loss at 100°	0·21	0·21
Loss by ignition	0·87	1·60
In solution in HCl :—		
$Fe_2O_3 + Al_2O_3$	0·97	2·34
CaO	—	1·01
MgO	0·13	0·22
SiO_2	0·66	1·20
Alkalis, &c. (by difference)	0·85	1·33
Insoluble in HCl	96·31	92·09

The small loss of 3·7 per cent. suffered by the sandstone under this severe treatment fully confirms the idea that this stone must lose by weathering with extreme slowness.

Professor Lebour kindly undertook a microscopic examination of a fine section of the sandstone prepared by Mr. G. Healey. He reported that 'the cementing material is undoubtedly crystalline barium sulphate,' and that 'besides the quartz grains, there are others of much the same average size and shape, the nature of which is not clear.' The quartz grains are 'more angular than rounded, and include narrow, rod-like crystals, which in all likelihood are apatite.'

The occurrence of barium sulphate as a cementing material in British sandstone has not been previously proved with certainty, although Mr. Aubrey Strahan, B.A., suspected its presence in the rock of Beeston Castle, Cheshire.[2] Mr. H. T. Brown, F.R.S., however, after examining specimens of the Beeston Castle rock in his pos-

[1] *Brit. Assoc. Report*, 1885, p. 1038.
[2] *Geol. Survey Memoirs*, 1882, pp. 7, 8.

session, proved the undoubted presence of barium, though entirely in the form of carbonate. Since this sandstone consists of the keuper basements beds, and belongs therefore to the same geological period as the beds at Bramcote, it becomes an interesting question to geologists whether barium compounds are in any way characteristic of the keuper sandstones. Bischof describes sandstone of character similar to the above as occurring in Münzenberg in the Witterau, and further mentions instances of disintegrated granite and of sand and clay being cemented by barium sulphate.

In discussing the curious nature of this sandstone with Professor Bedson, D.Sc., I was informed of the remarkable deposits, consisting largely of barium sulphate, which are rapidly formed in the pipes and water-boxes connected with the pumps of the Durham collieries. Mr. J. T. Dunn[1] mentions an instance of this deposition occurring so rapidly in the Jane Pit at Walker that a pipe of seven and a half square inches section was almost completely closed by it in the course of one autumn. Analysis of this deposit showed that it contained 90 per cent. of $BaSO_4$, 8 of $SrSO_4$, 1 of $CaSO_4$, and of small quantities of SiO_2, Al_2O_3, and Fe_2O_3.

Dr. Richardson[2] had already found a similar composition for an analogous pipe deposit. The further examination of these deposits appeared to me of interest in connection with the occurrence of the sandstone already referred to. I have accordingly made full analyses of several characteristic pipe deposits kindly furnished to me from the Durham College Museum by Professors Bedson and Lebour. The results obtained were as follows:—

—	Harton, box-deposit	Jane Pit, Walker, deposit	Newsham, box-deposit
Loss at 100°	0·83	0·26	0·39
Loss by ignition	2·15	1·51	1·95
$Fe_2O_3 + Al_2O_3$	5·44	0·12	0·37
BaO	56·72	61·30	61·09
SrO	trace	0·35	0·09
CaO	1·09	0·70	0·82
MgO	0·12	0·14	trace
SO_3	31·10	33·80	32·82
SiO_2	1·19	0·53	0·22
Alkalis, &c. (by difference)	1·36	1·29	2·25
$BaSO_4$	86·37	93·35	93·03

Professor Bedson[3] and others have found barium chloride to be a common constituent of the colliery waters of the Durham colliery district, and it would appear possible that the barium present in this form might be precipitated as sulphate in a more or less coherent state by coming into contact with water charged with sulphates resulting from the oxidation of the pyrites in the coal. The occurrence of barium sulphate in the Nottingham sandstone and in the Durham collieries may, however, have been due to the alteration into sulphate which barium carbonate can undergo when in contact with solutions of sulphates. Bischof has proved this by laboratory experiments (*loc. cit.*), and Haidinger has observed the process occurring in natural deposits of mountain limestone at Alston Moor.[4] The original deposit may therefore have been one of barium carbonate from water containing the bicarbonate in solution, and in the mine this may have undergone alteration from the products of oxidation of pyrites or from other soluble sulphates. In the case of the Nottingham sandstone the calcium sulphate which is present in abundance may have effected the change. Bischof also states that a hot spring may contain $BaCO_3$ and Na_2SO_4 together in solution, and deposit $BaSO_4$ only on cooling by

[1] *Trans. Newcastle Chem. Soc.* vol. iii. p. 261.
[2] *Brit. Assoc. Report*, 1863.
[3] *Journ. Soc. Chem. Ind.* vol. vi. p. 712.
[4] *Pogg. Ann.* vol. ii. p. 376.

an interchange of its constituents. There is at present little known to indicate which of the above processes, or whether any of them, have produced the above deposits, all attempts to trace their origin having thus far been inconclusive.[1]

WEDNESDAY, SEPTEMBER 18.

The following Report and Papers were read :—

1. *Second Report on the Higher Eocene Beds of the Isle of Wight.* See Reports, p. 89.

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2. *A word or two about the so-called Concretionary Structures in the Magnesian Limestone of Durham. By* Professor A. H. Green, *M.A., F.R.S.*

Parts of the magnesian limestone shown in the coast section north of Sunderland are largely made up of masses that assume various strange and fantastic shapes. It was suggested that these were originally tufaceous deposits, and that their form was in part due to irregular precipitation. In some cases subsequent molecular rearrangement had set up radiated and other crystalline structures in them.

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3. *The Work of the Geological Survey in Northumberland and Durham. By* W. Topley, *F.R.S., F.G.S.*

(*Communicated by permission of the Director-General.*)

The Geological Survey of Northumberland and Durham was commenced in 1864 (the year after the last meeting of the Association in Newcastle) by Mr. Howell, who superintended the work until its completion. The following officers of the Survey have, at various times, assisted in mapping the district: Messrs. Barrow, Burns, Cameron, Clough, Goodchild, Gunn, Lebour, Miller, and Topley.

The mapping has all been done on the 6-inch scale. Some of the 6-inch maps are published, others are deposited for reference in the Survey Office, London. All is reduced to the 1-inch scale. Of these maps two series are issued, one showing the glacial and other superficial deposits—'Drift Maps;' the other showing the rocks beneath the glacial deposits—'Solid Maps.' There are also 'Horizontal Sections' on the scale of 6 inches to a mile, 'Vertical Sections' on the scale of 40 feet to 1 inch; and Memoirs explanatory of the various 1-inch maps. An Index-map, on the scale of 4 miles to 1 inch, is in preparation.

Silurian rocks are exposed in the higher valleys of the Rede and Coquet, and a small faulted inlier, hitherto unknown, has been discovered near Ingram. Few fossils have been found on the English side of the Border, but they are more numerous on the Scottish side, and fix the age of the beds as Wenlock.

A small but important inlier of Silurian rocks was discovered by Messrs. Gunn and Clough in Teesdale, above the High Force. These beds belong to the Stockdale Shales; they are traversed by dykes of mica-trap. On the Yorkshire side of the Tees, near the same place, beds belonging to the Volcanic Series of the Lake District have been discovered.

The Cheviot area has yielded some interesting results. The general structure of this region, and the age of its rocks, were known to Mr. Tate, and the Geological Survey of Scotland worked out the details on the Scottish side before the English Survey had touched the English side. Indeed, the best general description of the district is that contributed to 'Good Words' by Professor James Geikie in 1876.

[1] The papers on which the above communication has been founded, have been published *in extenso* in the *Proc. Royal Soc.* vol. xlvi. pp. 363–369.

Granite has long been known to occur in the heart of the Cheviots, but its full importance was not recognised until Mr. Clough surveyed, and Mr. Teall showed that the granite contained augite, and hence belonged to a type of rock rather rare in Britain.

The greater part of the Cheviot area has been mapped by Mr. Clough. The geological history of the district is briefly as follows: Over the floor of Silurian rocks porphyrite lavas and ashes were erupted; associated with the porphyrite there are small patches of Lower Old Red Sandstone and Conglomerate.

The porphyrites differ in no essential respects from rocks of tertiary age, the hypersthene-, augite-, and mica-andesites being all well represented; the hornblende-andesites, however, are absent.

Intrusive through the porphyrites are numerous dykes of granite, felstone, quartz-felsite, and porphyrite; whilst the central area is occupied by a large intrusive mass of granite.

The granite sends veins into the porphyrite, but is itself traversed by some of the veins of felstone, porphyrite, &c., just mentioned.

The granite is, therefore, later than the main volcanic outburst of the district, but is earlier than some of the dykes.

The dykes roughly point towards the central region, as though radiating therefrom. Mr. Clough suggests that some dykes which in certain parts are granite become felstone or porphyrite dykes in other parts of their course.[1] The igneous rocks of the Cheviots are then approximately of the same age, the granite forming the core and central area of eruption.

These igneous rocks are all earlier than the lowest Carboniferous or Upper Old Red Sandstone, because the basement conglomerates contain fragments of Cheviot porphyrite and granite, whilst no porphyrite or granite dykes are known to enter the Carboniferous rocks.

The Carboniferous Limestone Series of Northumberland is of considerable interest, and it affords the key by which the beds in Scotland have been correlated with the typical areas in Central and Southern England. As shown in a paper by Mr. Hugh Miller, read at the Birmingham meeting of the Association (Report for 1886, p. 674), the classification proposed by the late G. Tate of Alnwick is applicable generally, with only slight modifications, to the whole of Northumberland.

The groups are, in descending order:—

Calcareous division.
Carbonaceous division.
Fell Sandstone series.
Cement-stone series.

Lower freestones and basement conglomerates.

The most striking physical feature is that at the base of the thick Fell Sandstones; these rocks form a range of craggy moorland throughout Northumberland, much broken, however, by faults in many places.

The top of the Fell Sandstones is less easily defined.

The base of the Calcareous Division is taken at the Dun Limestone, which is now known to be the same as the Redesdale Limestone of the centre and south of the county.

A well-marked horizon in the calcareous division is that of the great limestone, known as the 10-yard, and Dryburn limestone in North Northumberland. Workable seams of coal occur throughout the calcareous and carbonaceous division.

The detailed mapping of the beds has enabled the Survey to trace a great number of important lines of fault, the majority of which would have been unknown or at least very imperfectly understood but for such survey.

Amongst the special points of interest resulting from the survey of the Limestone Series the following may be mentioned: (*a*) A great part of the Calciferous Sandstone Series of Scotland is the equivalent of the true Carboniferous Limestone of central England; (*b*) The Scremerston coal seams must underlie the limestones

[1] See C. T. Clough, 'Geology of the Cheviot Hills' (*Mem. Geol. Survey*, Sheet 108 NE), 1888.

in South-eastern Berwickshire; (*c*) The same series of coals must be brought in by an important synclinal in the valley of the Till between Chillingham and Wooler; (*d*) The Lewisburn and Plashetts coals occur (as do the Scremerston seams) in the Carbonaceous division; (*e*) The discovery of an important fauna and flora in the cement-stone series of Northumberland, hitherto believed to be but sparsely fossiliferous. Over sixty species, including twelve plants, have been collected. Several new plants have been described by Mr. Kidston. Eight new schizopod crustaceans, and two or more scorpions, have been determined by Mr. Peach.[1]

The true Carboniferous Limestone fauna is especially characteristic of the limestones of the calcareous division, the shales and the ironstones of that division containing genera peculiar to themselves. Some beds of limestone are much more fossiliferous than others, and locally may be characterised by special fossils; but palæontology cannot be relied upon for fixing positions in the calcareous series. *Saccaminina Carteri*, supposed when first discovered to be confined to the four-fathom limestone, is now known to have a much wider range.

The lowest beds of the Carboniferous Series are coarse conglomerates; these are not continuous deposits, but seem often to have accumulated in sheltered hollows or bays. They are not always on the same horizon, but form local 'basement-beds.' That overlying the Silurian rocks of Teesdale is about 1,500 feet higher in the series than the basement conglomerate in parts of the Cross Fell escarpment.

The thickness of the various divisions varies much. The Fell sandstones attain their maximum thickness of about 2,000 feet at the Simonside Hills; they thin to about 500 feet to the west and north. The carbonaceous series attains its maximum thickness of nearly 3,000 feet in North Tynedale; the calcareous division its maximum (of about 3,500 feet) near the Wansbeck. The cement stone series is thickest west of Rothbury and again near the Tweed; in both districts it is about 1,500 feet thick. The limestones of this series are most fully developed west of Rothbury.

As regards the Coal-measures the Survey has, for the most part, merely been able to collect information from the mining engineers, and to trace the outcrops of the more important seams. The history of the coal-field was well worked out before the Survey came into the district. Perhaps the part least known was that north of the Wansbeck, and even now there are areas here as yet only partially understood. One of the most important seams north of the Wansbeck is the Ashington or Longhirst main seam. This was shown by the Survey to be the equivalent of the Grey seam.

The highest Coal-measures do not occur in the district; there is here a strong unconformity between the Carboniferous rocks and the Permian beds; the latter in South Durham sweeping over the edges of the former until they rest on the Carboniferous Limestone.

The occurrence of rock-salt in the lower part of the Triassic rocks near the Tees is a most important point in the geology of the district, but that question is fully dealt with by Messrs. Marley and Lebour in another paper.

Contemporaneous basaltic rocks occur in the lower part of the Carboniferous Limestone Series in Liddlesdale, in Cottonshope, Spithope, etc., and near Carham; but they are better developed on the Scottish side of the Border. They lie between the lower freestones and the cement-stone series.

The intrusive basaltic rocks occur in two forms—as 'sills' and as 'dykes.' The sills are sheets of basalt, lying in and between the sedimentary strata in such a manner as to have led some observers to believe the beds of trap to be contemporaneous; but evidence of intrusion is abundant elsewhere, and the basalt lies at very different horizons in different places. The Whin Sill usually occurs within the lower half of the calcareous division, but in North Northumberland it goes lower. In the south-west of the county, in the faulted coal-field of Midgeholm, a sill of basalt occurs in the Lower Coal-measures. The age of the Whin Sill is not known; it is probably late Carboniferous, or a little later. There is every reason to believe it to be pre-triassic.

[1] See Hugh Miller, 'Geology of Otterburn and Elsden' (*Mem. Geol. Survey*, Sheet 108SE), 1887.

The basaltic dykes are of two ages; some seem to be of about the same age as the Whin Sill. Indeed, small local 'sills' seem sometimes to have branched out from the dykes; and some dykes are apparently pre-permian. Other dykes are certainly much later, and no doubt belong to the great Tertiary volcanic outburst, the general history of which has been lately written by the Director-General of the Geological Survey. Some of the dykes which preserve so long a course through the country (such as the Cleveland and the Acklington dykes) belong to this later series.

The glacial and other drift deposits have throughout been mapped by the Survey on the six-inch scale; ice-marks and other phenomena connected with the glaciation of the district being also recorded.

The higher summits of the Cheviots, and the high areas of carboniferous rocks to the south-west of these, are believed by Mr. Clough to have acted as independent centres of glaciation, and never to have been overridden by any general ice-sheet; but all the rest of Northumberland has been covered by an ice-sheet, coming from the west on the south side of the Cheviots, and from the north and north-west on the north and east of the Cheviots. The glacial markings and other phenomena connected with the drift give evidence of this. In the county of Durham also there is a considerable area near Teesdale and Weardale that seems to have acted as an independent centre.

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4. *On Concurrent Faulting and Deposit in Carboniferous Times in Craven, Yorkshire, with a Note on Carboniferous Reefs. By* R. H. TIDDEMAN, *M.A., F.G.S.*

I propose to give briefly, in abstract only, some of the conclusions to which I have been drawn by a study of the rocks on both sides of the Craven fault in the district about Settle, Skipton, and Clitheroe during the progress of the Geological Survey, and these remarks are offered by permission of the Director-General.

The following subjects will be treated with all possible brevity:—

I. The range of the main branches of the Craven fault.

II. The nature, thicknesses, and extent of the rocks—

(i.) North of the faults;
(ii.) South of the same.

III. The questions suggested by the phenomena and the conclusions arrived at.

IV. A note on the existence of Carboniferous reefs in the district, their structure and probable mode of growth.

I. The Craven faults are well known to geologists, and have been treated of in the works of Sedgwick, John Phillips, and many others. The portions to which I shall allude in this paper extend from Ingleton, in the Lune basin, to beyond Grassington, in that of the Wharfe.

There are three principal lines of fault along this portion:—

(*a*) The northern runs from north of Ingleton and Clapham by Feizor, Stainforth in the Ribble Valley, Malham Tarn, Threshfield, to, and perhaps beyond, Pately Bridge.

(*b*) The Mid-Craven fault runs through Ingleton, only a short distance south of the other, and traverses Clapham, Austwick, thence below the picturesque Giggleswick Scars through the village of that name and Settle to Malham Cove and Gordale.

(*c*) A third fault, the South Craven fault, branches off from this near Settle, and, taking a more southerly course, passes by Scaleber Force and Holmes Gill Green to Gargrave and Skipton.

The greatest apparent depth of faulting is at Ingleton, where the Coal-measures are thrown down on a level with Silurian rocks; but as we follow the fractures to the east and south-east they branch off and become more in number and less in importance.

There are other minor faults, but those with which we are now chiefly concerned and which have caused the greatest results are the two first above mentioned. The effect of them is to throw down on the south and south-west.

The amount of displacement cannot always be determined, for reasons which will be apparent as we proceed.

II. The appended table gives a conspectus of the Carboniferous rocks in Craven and surrounding districts:—

It is necessary to call attention to these important facts:—

(1) That there are two distinct series, differing much from each other in thickness and grouping.

(2) That these two series have the chief Craven faults as their common boundary.

(3) That the series north of the Craven faults, which we may call the Yoredale type, extends over a wide area to the north; and that the south, or Clitheroe or Bowland type, extends over an equally large area to the south.

(4) That in the neighbourhood of the faults, which are their common boundary, there appears to be very little, if any, transition from the one type to the other, unless it be at the extreme ends, where the throw of the faults is considerably less.

(5) That the greater thicknesses are on the downthrow side of the faults.

Table of the Carboniferous Rocks in Craven.

Southern or Bowland Type	Feet		Feet	Northern or Yoredale Type	
COAL-MEASURES (Ingleton)	1,500	↑	—	COAL-MEASURES	Incomplete near the faults in this area
MILLSTONE GRITS . .	3,900		—	MILLSTONE GRITS	
BOWLAND SHALES . .	300 to 1,000	The great Craven faults	400–900	YOREDALE SERIES	
PENDLE-SIDE GRITS (inconstant)	0 to 250				
PENDLE-SIDE LIMESTONE (with Reefs)	0 to 400				
SHALES, WITH LIMESTONES	2,500		400–800	THE CARBONIFEROUS LIMESTONE (with conglomerates at base)	
CLITHEROE LIMESTONES (with Reefs)	+3,250 No base	↓			

Referring to the table, we see at once that it is impossible to institute any comparison between the *Coal-measures and Millstone grits*, because, though both are thrown against the faults between Ingleton and Settle on the south side, denudation has removed them from the north side, until we get so far away from the faults as to render any comparison of thickness worthless. Only small outliers of the lowest of the millstone grits occur on Ingleborough, Pennigent, Fountains Fell, &c. It is, however, worth while to note by the way that between Clitheroe and Burnley, to the south, the Carboniferous rocks are represented by upwards of three miles' thickness of rocks, without either base, which is not exposed, or Upper Coal-measures, which do not occur nearer than Manchester.

The *Yoredale series* are well known to contain a number of limestones, shales, and sandstones, of which the limestones are most constant, and run for many miles to the north with only slight changes, much slighter than might reasonably be expected considering the wide areas through which they range.

The *Bowland shales* consist of black calcareous shales only. Any limestones which occur in them are very exceptional, thin, inconstant, and insignificant. They

range over a wide area to the south of the faults, and impinge against them without showing any tendency to approach the type of the Yoredale series. I have, for purposes of classification, bracketed with them the Pendle-side grits, which are a very fickle set of sandbanks, frequently dying out and coming on again at about the same horizon. They may be equivalent to one of the sandstones of the Yoredale beds.

The Yoredale beds and Bowland shales I regard as synchronous on opposite sides of the faults. They are each, in their respective areas, below all the thick grits and above all the thick masses of limestone.

The Carboniferous Limestone proper of Ingleborough, Pennigent, Fountains Fell, &c., in the northern area, has within two miles of the faults a thickness of only 400 feet, including base. This may be compared with the following thicknesses within a small distance of the faults in the southern area, where the following members may be considered synchronous with it:—

	Feet
Pendle-side limestone	400
Shales, with limestone, &c.	2,500
The Clitheroe limestone	2,500
Giving a grand total of	5,400

and this without showing a base.

III. We are bound to find some explanation for the great discrepancies in series and thickness on opposite sides of the fault, and the fact of the faults forming the dividing line necessarily puts them under suspicion as having had something to do with it.

The great denudations which are well known to have taken place in Carboniferous rocks between their formation and the deposition of the Permian rocks have rendered possible the deposit of the latter on various members of the Carboniferous System at different horizons. Before these could be effected many of the earth movements must have taken place which folded and bent the Carboniferous rocks. So great are these movements, so enormous the denudation, that there is every probability that they began their work early.

This corroborates the view that *the faults were in the main acting during the deposition of the rocks*; though they probably went on before, and certainly after, that period. There are other sections in the surrounding country, apparent unconformities in the Carboniferous rocks, which are difficult to understand under any other supposition.

IV. *Note on Reefs.*—There are two distinct general types of limestone in the country south of the faults:

1. Black limestones with shaly bands, which appear for the most part to consist of organisms in a state of minute disintegration, although also containing scarcer complete specimens. These are always thinly and regularly bedded.
2. White to grey crystalline limestones of irregular form, and less visible bedding except in the mass and on the sides of the hills of which they consist.

These latter are crammed with brachiopoda, lamellibranchs, crinoids, corals, &c., many fairly perfect.

The forms of these mounds, resting as they often do upon the black limestones which have a very regular outcrop, and themselves presenting a sinuous outline, are extremely suggestive of the idea that they are reefs growing up, on a slowly sinking sea-bottom, from the life and death of the animals of whose remains they are composed. Moreover, at the foot of these mounds, or reef-knolls as I would call them, we have in many places a breccia formed of fragments of the limestone, which, I take it, have been broken off the reef above between wind and water, and have subsequently been covered up by the mud of the Bowland shales and compacted into a breccia. Fragments of limestone similarly consolidated occur, though more rarely, on the sides of these knolls themselves. I would call these reef-breccias.

A rather important result might accrue if these notions are correct.

If we could make out any particular zone in the limestones of these reefs, and

also find fragments of that zone at the foot of the reef in the breccia, we should have excellent data for determining the actual depth of the carboniferous sea at that particular point.

Postscript.—In speaking of the mounds as 'knoll-reefs' I do not wish necessarily to imply that they were *Coral-reefs.* They seem to have been built up in a somewhat similar way, but corals apparently only played a subordinate part in their formation.

Section D.—BIOLOGY.

President of the Section—Professor J. S. Burdon Sanderson, M.A., M.D., LL.D., F.R.SS.L. & E.

THURSDAY, SEPTEMBER 12.

The President delivered the following Address:—

Elementary Problems in Physiology.

It has long ceased to be possible in the course of an annual address in Section D. to give an account even of the most important advances which have been made during the preceding twelve months, in the various branches of knowledge which are now included under the term Biology. One reason is that each of the biological subjects has acquired such vast dimensions. The other, that the two main branches—Morphology, which strives to explain why plants and animals have assumed the forms and structure which they possess, and Physiology, which seeks to understand how the living organism works—have now diverged from each other so widely as regards subject and method, that there seems to be danger of complete separation of the one from the other.

From this sundering of sciences which a generation ago were intimately united, however inevitable it may be, Physiology chiefly suffers, as being even to the naturalist less attractive and interesting. The study of form and structure has the great advantage that it brings the observer into direct relation with objects which excite his curiosity without requiring too great an effort to understand them. This was the case even when Anatomy was mainly descriptive, and Zoology and Botany occupied themselves chiefly with classification and with definition of species. How much more is it the case now that Anatomy, Zoology, and Botany, have become built into one system of which the Doctrine of Evolution is the corner stone. Morphology, the name now given to this system, has, if I am not mistaken, this advantage over all other subjects of scientific study—that while attractive to the beginner, it is perfectly satisfactory to the mature student. It derives its perfectness from its subject—the *order* of the plant and animal world. For inasmuch as its fundamental conception is the development of all organisms, however complicated, from elementary forms, and as the theoretical development of the plant and animal world (in other words the science of morphology), claims to be nothing more than a synthesis of the observed facts of its actual development, thè science is co-ordinate and conterminous with living nature and strives after a perfection which is that of nature itself.

Physiology is without this source of attractiveness. Its first lessons present difficulties to the beginner which, unless he is contented (as indeed ordinary students are) to accept as true what he does not understand, are, to say the least, discouraging; while to the more mature student who has mastered more or less some part of the subject, it fails to present a system of knowledge of which all the parts are interdependent and can be referred to one fundamental principle, comparable to that of development or evolution.

It is easy to understand that this must be so if we consider the present position

of the subject, and the nature of the work which the physiologist has to do. That work is of two kinds. He has first to determine what are the chemical and physical endowments of living matter in general, and of each of the varieties of living matter which constitute the animal and plant organism in particular. Then, these having been investigated, he has to determine how these processes are localised so as to constitute the special function of each structure, and the relation between structure and process in each case. The order I have indicated is the logical order, but in the actual progress of physiology this order has not been followed, *i.e.* there has not been a correlation of structure with previously investigated process, for in former days physiologists spoke of assimilation, secretion, contraction and the like, as functions of muscles, glands, or other parts, without recognising their ignorance of their real nature. But now, no one who is awake to the tendencies of thought and work in physiology, can fail to have observed that the best minds are directed with more concentration than ever before to those questions which relate to the elementary endowments of living matter, and that if they are still held in the background it is rather because of the extreme difficulty of approaching them than from any want of appreciation of their importance.

It is to some of these questions that I am anxious to draw the attention of the Section to-day. I feel that I have set myself a difficult task, but think that, even should I succeed very partially, the attempt may be a useful one. And I am encouraged by the consideration that the interest they possess is one which is common to plant and animal physiology, and that if we really understood them, they would furnish a key, not only to the phenomena of nutrition and growth, but even to those of reproduction and development, and by the belief that it is in the direction of elementary physiology, which means nothing more than the study of the endowments of living material, that the advance of the next twenty years will be made.

Nearly fifty years ago, J. R. Mayer's[1] treatise on the relation between organic motion and the exchange of material in living organisms was published in Germany. Although its value was more appreciated by physicists than by biologists, it was in its purpose, as well as in its subject-matter, physiological. In it Mayer showed for the first time that certain functions of the animal body, which up to that time had been considered most vital, are strictly within reach of measurement, *i.e.* referable to physical standards of quantity. He was even able to demonstrate that those quantitative relations between different kinds of energy which physicists were then only beginning to recognise, held good as regards the processes peculiar to the living organism.

Almost immediately after the appearance of this now celebrated work, a series of discoveries were made in physiology, which constituted the period we are now considering an epoch. Mayer himself had proved that muscles in doing work and producing heat do not do so at the expense of their own substance. But this fact could not be understood until Bernard showed that sugar is one of the most important constituents of the blood, and its storage and production a chief function of the liver. Helmholtz next succeeded in proving what Johannes Müller[2] had declared to be nearly impossible, namely, that the time occupied by the propagation of a motor impulse from the brain to a muscle could be measured, and showed it to be proportional to the distance traversed. Next, du Bois-Reymond investigated the electrical phenomena of living beings, and marshalled them under a physical theory which stood its ground against the severest criticism for more than a generation. And finally the hydrodynamic principles relating to the circulation, set forth by Dr. Thomas Young in his Croonian Lecture forty years before, were demonstrated experimentally by Ludwig, at the very time when Helmholtz was giving definite form to the great natural philosopher's Theory of Colour Perceptions.

The effect of these discoveries was to produce a complete revolution in the

[1] J. R. Mayer, *Die organische Bewegung in ihrem Zusammenhange mit dem Stoffwechsel.* Heilbronn. 1845.

[2] Müller's *Physiology.* Translation of 2nd edition, p. 729.

ways of thinking and speaking about the phenomena of life. The error of the past had been to believe that, although the heart resembled a pump, although digestion could be imitated in the laboratory, and comparisons of vital with physical processes could be used for illustration, it was always wrong to identify them. But, inasmuch as it had been learned that sensation is propagated along a nerve just as sound is propagated through the air, only with something like a tenth of the velocity; that the relations between the work done, the heat produced, and the fuel used, can be investigated in the living body just as they are in the steam engine, it now came to be felt that in other similar cases, what had been before regarded as peculiarly vital might be understood on physical principles, and that for the future the word 'vital' as distinctive of physiological processes might be abandoned altogether. In looking back, we have no difficulty in seeing that the lines of investigation which were then initiated by such men as Helmholtz, Ludwig, Brücke, du Bois-Reymond, Donders, Bernard, are those along which, during the succeeding generation, the science of physiology advanced; nor can anyone who is acquainted with the literature of that time doubt that these leaders of physiological thought knew that they were the beginners of a new epoch. But such an epoch cannot occur again. We have adopted once for all the right, *i.e.* the scientific method, and there is not the least possibility of our recurring to the wrong. We have no new departure, no change of front in prospect; but even times which are not epochal have their tendencies, and I venture to submit to you, that in physiology the tendency of the present time is characterised by the concentration of the best efforts of the best minds on what I have already referred to as elementary questions. The work of investigating the special functions of organs, which during the last two decades has yielded such splendid results, is still proceeding, and every year new ground is being broken and new and fruitful lines of experimental inquiry are being opened up; but the further the physiologist advances in this work of analysis and differentiation, the more frequently does he find his attention arrested by deeper questions relating to the essential endowments of living matter, of which even the most highly differentiated functions of the animal or plant organism are the outcome. In our science the order of progress has been hitherto and will continue to be the reverse of the order of nature. Nature begins with the elementary and ends with the complex (first the amœba, then the man). Our mode of investigation has to begin at the end. And this not merely for the historical reason that the first stimulus to physiological inquiry was man's reasonable desire to know himself, but because differentiation actually involves simplification. For just as in manufactures it is the effect of division of labour that less is required of each workman, so in an organism which is made up of many organs, the function of each is simpler.

Physiology, therefore, first studies man and the higher animals and proceeds to the higher plants, then to invertebrates and cryptogams, ending where development begins. From the beginning her aim has been to correlate function with structure, at first roughly, afterwards, when, as I have explained, her methods of observation became scientific, more and more accurately; the principle being that *every appreciable difference of structure corresponds to a difference of function*; and conversely that each endowment of a living organ must be explained, if explained at all, as springing from its structure.

It is not difficult to see whither this method must eventually lead us. For inasmuch as function is more complicated than structure, the result of proceeding, as physiology normally does, from structure to function, must inevitably be to bring us face to face with functional differences which have no structural difference to explain them. Thus, for example, if the physiologist undertakes to explain the function of a highly differentiated organ like the eye, he finds that up to a certain point, provided that he has the requisite knowledge of dioptrics, the method of correlation guides him straight to his point. He can mentally or actually construct an eye which will perform the functions of the real eye, in so far as the formation of a real image of the field of vision on the retina is concerned, and will be able thereby to understand how the retinal picture is transferred to the organ of consciousness. Having arrived at this point he begins to correlate the known structure

of the retina with what is required of it, and finds that the number of objects which he can discriminate in the field of vision is as numerous as, but not more numerous than, the parts of the retina, *i.e.* the cones which are concerned in discriminating them. So far he has no difficulty; but the method of correlation fails him from the moment that he considers that each object point in the field of vision is coloured, and that he is able to discriminate not merely the number and the relations of all the object points to each other, but the colour of each separately. He then sees at once that each cone must possess a plurality of endowments for which its structure affords no explanation. In other words, in the minute structure of the human retina, we have a mechanism which would completely explain the picture of which we are conscious, were the objects composing it colourless, *i.e.* possessed of one objective quality only, but it leaves us without explanation of the differentiation of colour.

Similarly, if we are called upon to explain the function of a secreting gland, such, *e.g.*, as the liver, there is no difficulty in understanding that, inasmuch as the whole gland consists of lobules which resemble each other exactly, and each lobule is similarly made up of cells which are all alike, each individual cell must be capable of performing all the functions of the whole organ. But when by exact experiment we learn that the liver possesses not one function but many—when we know that it is a storehouse for animal starch, that each cell possesses the power of separating waste colouring matter from the blood, and of manufacturing several kinds of crystallisable products, some of which it sends in one direction and others in the opposite, we find again that the correlation method fails us, and that all that our knowledge of the minute structure has done for us is to set before us a question which, though elementary, we are quite unable to answer.

By multiplying examples of the same kind, we should in each case come to the same issue, namely, *plurality of function with unity of structure*, the unity being represented by a simple structural element—be it retinal cone or cell—possessed of numerous endowments. Whenever this point is arrived at in any investigation, structure must for the moment cease to be our guide, and in general, two courses or alternatives are open to us. One is to fall back on that worn-out *Deus ex machinâ*, protoplasm, as if it afforded a sufficient explanation of everything which cannot be explained otherwise, and accordingly to defer the consideration of the functions which have no demonstrable connection with structure as for the present beyond the scope of investigation; the other is, retaining our hold of the fundamental principle of correlation, to take the problem in reverse, *i.e.* to use analysis of function as a guide to the ultra-microscopical analysis of structure.

I need scarcely say that of these two courses the *first* is wrong, the *second* right, for in following it we still hold to the fundamental principle that *living material acts by virtue of its structure*, provided that we allow the term structure to be used in a sense which carries it beyond the limits of anatomical investigation, *i.e.*, beyond the knowledge which can be attained either by the scalpel or the microscope. We thus (as I have said) proceed from function to structure, instead of the other way.

The departure from the traditions of our science which this change of direction seems to imply is indeed more apparent than real. In tracing the history of some of the greatest advances, we find that the recognition of function has preceded the knowledge of structure. Haller's discovery of irritability was known and bore fruit, long before anything was known of the structure of muscle. So also, at a later period, Bichat was led by his recognition of the physiological differences between what he termed the functions of organic and animal life, to those anatomical researches which were the basis of the modern science of Histology. Again, in much more recent times, the investigation of the function of gland cells, which has been carried on with such remarkable results by Professor Heidenhain in Germany, and with equal success by Mr. Langley in this country, has led to the discovery of the structural changes which they undergo in passing from the state of repose to that of activity; nor could I mention a better example than that afforded (among many others relating to the physiology of the nervous system) by Dr. Gaskell's recent and very important discovery of the

anatomical difference between cerebro-spinal nerves of different functions. We may therefore anticipate that the future of physiology will differ from the past chiefly in this respect—that whereas hitherto the greater part of the work has consisted in the interpretation of facts arrived at in the first instance by anatomical methods of research, Histology, once the guide of Physiology, has now become her handmaid.

During the last ten or fifteen years histology has carried her methods of research to such a degree of perfection that further improvement scarcely seems possible. As compared with these subtle refinements, the 'minute anatomy' of thirty years ago appears coarse—the skill for which we once took credit seems but clumsiness. Notwithstanding, the problems of the future from their very nature lie as completely out of reach of the one as of the other. It is by different methods of investigation that our better equipped successors must gain insight of those vital processes of which even the ultimate results of microscopical analysis will ever be, as they are now, only the outward and visible signs.

The Invisible Mechanism of Life.

In what has preceded I have endeavoured to show that at present the fundamental questions in physiology, the problems which most urgently demand solution, are those which relate to the endowments of apparently structureless living matter, and that the most important part of the work of the immediate future will be the analysis of these endowments. With this view what we have to do is, first, to select those cases in which the vital process offers itself in its simplest form, and is consequently best understood; and, secondly, to inquire how far in these particular instances we may, taking as our guide the principle I have so often mentioned as fundamental, viz. the correlation of structure with function, of mechanism with action, proceed in drawing inferences as to the mechanism by which these vital processes are in these simplest cases actually carried out.

The most distinctive peculiarity of living matter as compared with non-living is that it is ever changing while ever the same, *i.e.* that life is a state of ceaseless change. For our present purpose I must ask you, first, to distinguish between two kinds of change which are equally characteristic of living organisms, namely, those of growth and decay on the one hand, and those of nutrition on the other. Growth the biologist calls evolution. Growth means the unfolding, *i.e.* development of the latent potentialities of form and structure which exist in the germ, and which it has derived by inheritance. A growing organism is not the same to-day as it was yesterday, and consequently not quite the same now as it was a minute ago, and never again will be. This kind of change I am going to ask you to exclude from consideration altogether at this moment, for in truth it does not belong to Physiology but rather to Morphology, and to limit your attention to the other kind which includes all other vital phenomena. I designated it just now as nutrition, but this word expresses my meaning very inadequately. The term which has been used for half a century to designate the sum or complex of the non-developmental activities of an organism is 'exchange of material,' for which Professor Foster has given the very acceptable substitute Metabolism. Metabolism is only another word for 'change,' but in using it we understand it to mean that, although an organism in respect of its development may never be what it has been, the phases of alternate activity and repose which mark the flow of its life-stream are recurrent. Life is a Cyclosis in which the organism returns after every cycle to the same point of departure, ever changing yet ever the same.

It is this antithesis which constitutes the essential distinction between the two great branches of biology, the two opposite aspects in which the world of life presents itself to the inquiring mind of man. Seen from the morphological side the whole plant and animal kingdom constitutes the unfolding of a structural plan which was once latent in a form of living material of great apparent simplicity. From the physiological side this apparently simple material is seen to be capable

of the discharge of functions of great complexity, and therefore must possess corresponding complexity of mechanism. It is the nature of this invisible mechanism that physiology thirsts to know. Although little progress has as yet been made, and little may as yet be possible, in satisfying this desire, yet, as I shall endeavour to show you, the existing knowledge of the subject has so far taken consistent form in the minds of the leaders of physiological thought, that it is now possible to distinguish the direction in which the soberest speculation is tending.

The *non-developmental* vital functions of protoplasm are the absorption of oxygen, the discharge of carbon dioxide and water and ammonia, the doing of mechanical work, the production of heat, light, and electricity. All these, excepting the last, are known to have chemical actions as their inseparable concomitants. As regards electricity we have no proof of the dependence of the electrical properties of plants and animals on chemical action. But all the other activities which have been mentioned are fundamentally chemical.

The Ultra-Microscopical Structure of Living Material.

Let us first consider the relation of oxygen to living matter and vital process. For three quarters of a century after the fundamental discoveries of Lavoisier and Priestley (1772–76), the accepted doctrine was that the effete matter of the body was brought to the lungs by the circulation and burnt there, of which fact the carbon dioxide expired seemed an obvious proof. Then came the discovery that arterial blood contained more oxygen than venous blood, and consequently that oxygen must be conveyed as such by the blood stream to do its purifying work in all parts of the body, this advance in the understanding of the process being crowned a few years later by the discovery of the oxygen-carrying properties of the colouring matter of the blood, in which the present President of the Royal Society took so prominent a part. Finally, between 1872 and 1876, as the result of an elaborate series of investigations of the respiratory process, the proof was given by Pflüger [1] that the function of oxygen in the living organism is not to destroy effete matter either here or there, but rather to serve as a food for protoplasm, which so long as it lives is capable of charging itself with this gas, absorbing it with such avidity, that although its own substance retains its integrity, no free oxygen can exist in its neighbourhood. This discovery, of which the importance is comparable with that of Lavoisier, can best be judged of by considering its influence on other fundamental conceptions of the vital process. The generally accepted notion of effete matter waiting to be oxidised was associated with a more general one, viz. that the elaborate structure of the body was not permanent, but constantly undergoing decay and renewal. What we have now learnt is, that the material to be oxidised comes as much from the outside as the oxygen which burns it, though the reaction between them, *i.e.*, the oxidation, is intrinsic, *i.e.*, takes place within the living molecular framework.

Protoplasm, therefore, understanding by the term the visible and tangible presentation to our senses of living material, comes to consist of two things—namely, of framework and of content—of channel and of stream—of acting part which lives and is stable—of acted-on part which has never lived and is labile, that is, in a state of metabolism, or chemical transformation.

If such be the relation between the living framework and the stream which bathes it, we must attribute to this living, stable, acting part a property which is characteristic of the bodies called in physiological language ferments, or enzymes, the property which, following Berzelius, we have for the last half century expressed by the word *catalytic*; and use, without thereby claiming to understand it, to indicate a mode of action in which the agent which produces the change does not itself take part in the decompositions which it produces.

[1] Pflüger's *Archiv*, vol. vi., 1872, p. 43, and vol. x., 1875, p. 251. 'Ueber die physiologische Verbrennung in den lebendigen Organismen.'

Micellæ and Tagmata (*Nägeli*, *Pfeffer*).

I have brought you to this point as the outcome of what we know as to the essential nature of the all-important relation between oxygen and life. In botanical physiology the general notion of a stable catalysing framework, and of an interstitial labile material, which might be called catalyte, has been arrived at on quite other grounds. This notion is represented in plant physiology by two words, both of which correspond in meaning—Micellæ, the word devised by Nägeli, and the better word, Tagmata, substituted for it by Pfeffer. Nägeli's word has been adopted by Professor Sachs as the expression of his own thought in relation to the ultra-microscopical structure of the protoplasm of the plant cell. His view is that certain well-known properties of organised bodies require for their explanation the admission that the simplest *visible* structure is itself made up of an arrangement of units of a far inferior order of minuteness. It is these hypothetical units that Nägeli has called Micellæ.

Now, Nägeli [1] in the first instance confounded the micellæ with molecules, conceiving that the molecule of living matter must be of enormous size. But, inasmuch as we have no reason for believing that any form of living material is chemically homogeneous, it was soon recognised, perhaps first by Pfeffer,[2] but eventually also by Nägeli himself, that a micella, the ultimate element of living material, is not equivalent to a molecule, however big or complex, but must rather be an arrangement or phalanx of molecules of different kinds. Hence the word Tagma, first used by Pfeffer, has come to be accepted as best expressing the notion. And here it must be noted that each of the physiologists to whom reference has been made regards the micellæ, not as a mere aggregate of separate particles, but as connected together so as to form a system—a conception which is in harmony with the view I gave you just now from the side of animal physiology, of catalysing framework and interstitial catalysable material.

To Professor Sachs, this porous constitution of protoplasm serves to explain the property of vital turgescence, that is, its power of charging itself with aqueous liquid—a power which Sachs estimates to be so enormous that living protoplasm may, he believes, be able to condense water which it takes into its interstices, to less than its normal volume. For our present purpose it is sufficient for us to understand that to the greatest botanical thinkers, as well as to the greatest animal physiologists, the ultimate mechanism by which life is carried on is not, as Professor Sachs [3] puts it, 'slime,' but 'a very distensible and exceedingly fine network.'

Ino-tagmata (*Engelmann*, *Pflüger*, *Bernstein*).

And now let us try to get a step further by crossing back in thought from plants to animals. At first sight, the elementary vital processes of life seem more complicated in the animal than in the plant, but they are, on the contrary, simpler; for plant protoplasm, though it may be structurally homogeneous, is dynamically polyergic—it has many endowments—whereas in the animal organism there are cases in which a structure has only one function assigned to it. Of this the best examples are to be found among so-called excitable tissues, viz. those which are differentiated for the purpose of producing (along with heat) mechanical work, light, or electricity. In the life of the plant these endowments, if enjoyed at all, are enjoyed in common with others.

By the study, therefore, of muscle, of light organ and of electrical organ, the vital mechanism is more accessible than by any other portal. About light organs we as yet know little, but the little we know is of value. Of electrical organs rather more, about muscle a great deal.

To the case of muscle, Engelmann, one of the best observers and thinkers on the elementary questions which we have now before us, has transferred the

[1] Nägeli, 'Theorie der Gährung,' *Beitrag zur Molecular Physiologie*, 1879, p. 121.

[2] Pfeffer, *Pflanzenphysiologie*, Leipsic, 1881, p. 12.

[3] Sachs, *Experimental-Physiologie*, 1865, p. 443; and *Lectures on the Physiology of Plants*, English translation, p. 206.

terminology of Nägeli and Pfeffer as descriptive of the mechanism of its contraction. Muscular protoplasm differs from those kinds of living matter to which I have applied the term 'polyergic,' in possessing a molecular structure comparable with that of a crystal in this respect, that each portion of the apparently homogeneous and transparent material of which it consists resembles every other.

With this ultra-microscopical structure, its structure as investigated by the microscope may be correlated, the central fact being that, just as a muscular fibre can be divided into cylinders by cross sections, so each such cylinder is made up of an indefinite number of inconceivably minute cylindrical parts, each of which is an epitome of the whole. These, Engelmann, following Pfeffer, calls ino-tagmata. So long as life lasts each minute phalanx has the power of keeping its axis parallel with those of its neighbours, and of so acting within its own sphere as to produce, whenever it is awakened from the state of rest to that of activity, a fluxion from poles to equator. In other words, muscle, like plant protoplasm, consists of a stable framework of living catalysing substance, which governs the mechanical and chemical changes which occur in the interstitial catalysable material, with this difference, that here the ultra-microscopical structure resembles that of a uniaxial crystal, whereas in plant protoplasm there may be no evidence of such arrangement.[1]

According to this scheme of muscular structure, the contraction, *i.e.*, the change of form which, if allowed, a muscle undergoes when stimulated, has its seat not in the system of tagmata, but in the interstitial material which surrounds it, and consists in the migration of that labile material from pole to equator, this being synchronous with explosive oxidation, sudden disengagement of heat, and change in the electrical state of the living substance. Let us now see how far the scheme will help us to an understanding of this marvellous concomitance of chemical, electrical, and mechanical change.

It is not necessary to prove to you that the discharge of carbon dioxide and the production of heat which we know to be associated with that awakening of a muscle to activity which we call stimulation, are indices of oxidation. If we take this fact in connection with the view that has just been given of the mechanism of contraction, it is obvious that there must be in the sphere of each tagma an accumulation of oxygen and oxidisable material, and that concomitantly with or antecedently to the migration of liquid from pole to equator, these must come into encounter. Let us for a moment suppose that a soluble carbohydrate is the catalysable material, that this is accumulated equatorially, and oxygen at the poles, and consequently that between equator and poles water and carbon dioxide, the only products of the explosion, are set free. That the process is really of this nature is the conclusion to which an elaborate study of the electrical phenomena which accompany it has led one of the most eminent physiologists of the present time, Professor Bernstein.[2] To this I wish for a moment to ask your attention.

Professor Bernstein's view of the molecular structure of muscular protoplasm is in entire accordance with the theory of Pflüger and with the scheme of Engelmann, with this addition, that each ino-tagma is electrically polarised when in a state of rest, depolarised at the moment of excitation or stimulation, and that the axes of the tagmata are so directed that they are always parallel to the surface of the fibre, and consequently have their positive sides exposed. In this amended form, the theory admits of being harmonised with the fundamental facts of muscle-electricity, namely, that cut surfaces are negative to sound surfaces, and excited parts to inactive, provided that the direction of the hypothetical polarisation is from equator to pole, *i.e.* that in the resting state the poles of each tagma are charged with negative ions, the equators with positive; and consequently that the direction of the discharge in the catalyte at the moment that the polarisation disappears is from pole to equator.

[1] Brücke, *Vorlesungen*, 2nd edition, vol. ii., p. 497.

[2] Bernstein, 'Neue Theorie der Erregungsvorgänge und electrischen Erscheinungen an den Nerven- und Muskelfasern,' *Untersuchungen aus dem Physiologischen Institut*, Halle, 1888.

Time forbids me even to attempt to explain how this theory enables us to express more consistently the accepted explanations of many collateral phenomena, particularly those of electrotonus. I am content to show you that it is not impossible to regard the three phenomena, viz., chemical explosion, sudden electrical change, and change of form, as all manifestations of one and the same process—as products of the same mechanism.

In plants, in certain organs or parts in which movement takes place as in muscles in response to stimulation, the physiological conditions are the same or similar, but the structural very different; for the effect is produced not by a change of form, but by a diminution of volume of the excited part, and this consists not of fibres but of cells. The way in which the diminution of volume of the whole organ is brought about is by diminution of the volume of each cell, an effect which can obviously be produced by flow of liquid out of the cell. At first sight therefore the differences are much more striking than the resemblances.

But it is not so in reality. For the more closely we fix our attention on the elementary process rather than on the external form, the stronger appears the analogy—the more complete the correspondence. The state of turgor, as it has been long called by botanical physiologists, by virtue of which the framework of the protoplasm of the plant retains its content with a tenacity to which I have already referred, is the analogue of the state of polarisation of Bernstein. As regards its state of aggregation it can scarcely be doubted that inasmuch as the electrical concomitants of excitation of the plant cell so closely correspond with those of muscle, here also the tagmata are cylindrical, and have their axes parallel to each other. Beyond this we ought perhaps not to allow speculation to carry us, but it is scarcely possible to refrain from connecting this inference with the streaming motion of protoplasm which in living plant cells is one of the indices of vitality. If, as must I think be supposed, this movement is interstitial, *i.e.* due to the mechanica action of the moving protoplasm on itself, we can most readily understand its mechanism as consisting in rhythmically recurring phases of close and open order in the direction of the tagmatic axes.

In submitting this hypothesis I do not for a moment forget that the facts relating to the contractility of plant cells have as yet been insufficiently investigated. No one has as yet shown that when the leaf of the sensitive plant falls, or that of the flytrap closes on its prey, heat is developed or oxidation takes place, but it does not seem to me very rash to anticipate that if it were possible to make the experiment to-morrow it would be found to be so.

Anabolism and Catabolism.

I have thus endeavoured, building on two principles in physiology, firstly, that of the constant correlation of mechanism and action, of structure and function, and secondly, the identity of plant and animal life both as regards mechanism and structure—and on two experimentally ascertained elementary relations, viz. the relation of living matter or protoplasm to water on the one hand and to oxygen and food on the other—to present to you in part the outline or sketch of what might, if I had time to complete it, be an adequate conception of the mechanism and process of life as it presents itself under the simplest conditions. To complete this outline, so far as I can to-day, I have but one other consideration to bring before you, one which is connected with the last of my four points of departure—that of the relation of oxygen to protoplasm, a relation which springs out of the avidity with which, without being oxidised or even sensibly altered in chemical constitution, it seizes upon oxygen and stores it for its own purposes. The consideration which this suggests is that if the oxygen and oxidisable material are constantly stored, they must either constantly or at intervals be discharged, and inasmuch as we know that in every instance without exception in which heat is produced or work is done, these processes have discharge of water and of carbon dioxide for their concomitants, we are justified in regarding these discharges as the sign of expenditure, the charging with oxygen as the sign of restitution. In other words, a new characteristic of living process springs out of those we have already

had before us, namely, that it is a constantly recurring alternation of opposite and complementary states, that of activity or discharge, that of rest or restitution.

Is it so or is it not? In the minds of most physiologists the distinction between the phenomena of discharge and the phenomena of restitution (*Erholung*) is fundamental, but beyond this, unanimity ceases. Two distinguished men, one in Germany and one in England, I refer to Professor Hering and Dr. Gaskell, have taken, on independent grounds, a different view to the one above suggested, according to which life consists not of alternations between rest and activity, charge and discharge, loading and exploding, but between two kinds of activity, two kinds of explosion, which differ only in the direction in which they act, in the circumstance that they are antagonistic to each other.

Now when we compare the two processes of rest, which as regards living matter means restitution, and discharge which means action, with each other, they may further be distinguished in this respect, that, whereas restitution is autonomic, *i.e.* goes on continuously like the administrative functions of a well-ordered community, the other is occasional, *i.e.*, takes place only at the suggestion of external influences; that, in other words, the contrast between action and rest is (in relation to protoplasm) essentially the same as between waking and sleeping.

It is in accordance with this analogy between the alternation of waking and sleeping of the whole organism, and the corresponding alternation of restitution and discharge, of every kind of living substance, that physiologists by common consent use the term Stimulus (*Reiz*), meaning thereby nothing more than that it is by external disturbing or interfering influence of some kind that energies stored in living material are (for the most part suddenly) discharged. Now, if I were to maintain that restitution is not autonomic, but determined, as waking is, by an external stimulus—that it differed from waking only in the direction in which the stimulation acts, *i.e.* in the tendency towards construction on the one hand, towards destruction on the other, I should fairly and as clearly as possible express the doctrine which, as I have said, the two distinguished teachers I have mentioned, viz., Dr. Gaskell and Professor Hering,[1] have embodied in words which have now become familiar to every student. The words in question, 'anabolism,' which being interpreted means winding up, and 'catabolism,' running down, are the creation of Dr. Gaskell. Professor Hering's equivalents for these are 'assimilation,' which, of course, means storage of oxygen and oxidisable material, and 'disassimilation,' discharge of these in the altered form of carbon dioxide and water. But the point of the theory which attaches to them lies in this, that that wonderful power which living material enjoys of continually building itself up out of its environment, is, as I have already suggested, not autonomic, but just as dependent on occasional and external influences, or stimuli, as we know the disintegrating processes to be; and accordingly Hering finds it necessary to include under the term stimuli not only those which determine action, but to create a new class of stimuli which he calls *Assimilations-Reize*, those which, instead of waking living mechanism to action, provoke it to rest.

It is unfortunately impossible within the compass of an address like the present to place before you the wide range of experimental facts which have led two of the strongest intellects of our time to adopt a theory which, when looked at *à priori*, seems so contradictory. I must content myself with mentioning that Hering was led to it chiefly by the study of one of the examples to which I referred in my introduction, namely, the colour-discriminating function of the retina, Dr. Gaskell by the study of that very instructive class of phenomena which reveal to us that among the channels by which the brain maintains its sovereign power as supreme regulator of all the complicated processes which go on in the different parts of the animal organism, there are some which convey only commands to action, others commands to rest, the former being called by Gaskell catabolic, the latter anabolic. To go further than this would not only wear out your patience but

[1] Hering, *Zur Theorie der Vorgänge in der lebendigen Substanz*, Prague, 1888, pp. 1–22. See also a paper by Dr. Gaskell in Ludwig's *Festschrift*, Leipsic, 1888, p. 115.

would carry me beyond the limits I proposed to myself, viz. the mechanism of life in its simplest aspects. I therefore leave the subject here, adding one word only. The distinction which has suggested to their authors the words on which I have been commenting is a real one, but it implies rather the interference with each other of the simultaneous operation of two regulating mechanisms, than an antagonism between two processes of opposite tendencies carried on by the same mechanism; or, putting it otherwise, that the observed antagonism is between one nervous mechanism and another, and not between two antagonistic functions of the same living material.

Vitalism.

Without attempting to recapitulate, I have a word to say by way of conclusion on a question which may probably have suggested itself to some of my audience.

I have indicated to you that although scientific thought does not, like speculative, oscillate from side to side, but marches forward with a continued and uninterrupted progress, the stages of that progress may be marked by characteristic tendencies; and I have endeavoured to show that in physiology the questions which concentrate to themselves the most lively interest are those which lie at the basis of the elementary mechanism of life.

The word Life is used in physiology in what, if you like, may be called a technical sense, and denotes only that state of *change with permanence* which I have endeavoured to set forth to you. In this restricted sense of the word, therefore, the question 'What is Life?' is one to which the answer is approachable; but I need not say that in a higher sense—higher because it appeals to higher faculties in our nature—the word suggests something outside of mechanism, which may perchance be its cause rather than its effect.

The tendency to recognise such a relation as this is what we mean by vitalism. At the beginning of this discourse I referred to the anti-vitalistic tendency which accompanied the great advance of knowledge that took place at the middle of the century. But even at the height of this movement there was a reaction towards vitalism, of which Virchow,[1] the founder of modern pathology, was the greatest exponent. Now, a generation later, a tendency in the same direction is manifesting itself in various quarters. What does this tendency mean? It has to my mind the same significance now that it had then. Thirty years ago the discovery of the cell as the basis of vital function was new, and the mystery which before belonged to the organism was transferred to the unit, which while it served to explain everything was itself unexplained. The discovery of the cell seemed to be a very close approach to the mechanism of life, but now we are striving to get even closer, and with the same result. Our measurements are more exact, our methods finer; but these very methods bring us to close quarters with phenomena which, although within reach of exact investigation, are as regards their essence involved in a mystery which is the more profound the more it is brought into contrast with the exact knowledge we possess of surrounding conditions.

If what I have said is true, there is little ground for the apprehension that exists in the minds of some that the habit of scrutinising the mechanism of life tends to make men regard what can be so learned as the only kind of knowledge. The tendency is now certainly rather in the other direction. What we have to guard against is the mixing of two methods, and, so far as we are concerned, the intrusion into our subject of philosophical speculation. Let us willingly and with our hearts do homage to 'divine Philosophy,' but let that homage be rendered outside the limits of our science. Let those who are so inclined cross the frontier and philosophise; but to me it appears to be more conducive to progress that we should do our best to furnish professed philosophers with such facts relating to structure and mechanism as may serve them as aids in the investigation of those deeper problems which concern man's relations to the past, the present, and the unknown future.

[1] Virchow, 'Alter und neuer Vitalismus,' *Archiv für path. Anat.*, 1856, vol. ix., p. 1. See also Rindfleisch, *Aerztliche Philosophie*, Würzburg, 1888, pp. 10–13.

The following Reports and Papers were read:—

1. *Report of the Committee on the Natural History of the Friendly Islands, or other groups in the Pacific, visited by H.M.S. 'Egeria.'*—See Reports, p. 113.

2. *Second Report of the Committee for reporting on the present state of our knowledge of the Zoology and Botany of the West India Islands, and taking steps to investigate ascertained deficiencies in the Fauna and Flora.*—See Reports, p. 93.

3. *Second Report of the Committee on the development of the Oviduct and connected structures in certain fresh-water Teleostei.*—See Reports, p. 95.

4. *Second Report of the Committee for collecting information as to the Disappearance of Native Plants from their Local Habitats.*—See Reports, p. 435.

5. *Report of the Committee for making a digest of the observations on Migration of Birds.*—See Reports, p. 114.

6. *Report of the Committee to arrange for the occupation of a Table at the Zoological Station at Naples.*—See Reports, p. 95.

7. *Third Report of the Committee for continuing the preparation of a report on our present knowledge of the Flora of China.*—See Reports, p. 112.

Zoological Department.

1. *Notes on the Fauna of the Louisiade and d'Entrecasteaux Islands.* *By* Basil H. Thomson.

An official expedition was made in October last to these islands in order to open communication with the natives on behalf of the colonial government of Sydney. The paper enumerated the more remarkable of the Lepidoptera, Orthoptera, Coleoptera, and land molluscs of the islands, and described the distinctive physical characters of each island. Of the birds two remarkable species, *Paradisea decora* and *Manucodia comrii* are confined to the d'Entrecasteaux Islands exclusively, the former to one mountain in Fergusson Island. Their habits were described. Normanby Island is the eastern limit of the Wallaby. Of nineteen species of diurnal lepidoptera in the d'Entrecasteaux eight proved to be new. The only species of coleoptera described in Rossel Island were both new. No new reptilian forms were discovered, but several very rare species. The mammalia consisted of Wallabys (two species), opossums (two species), a fruit-eating bat, and a peculiar rat. Of fourteen species of land molluscs ten proved to be new, making twenty-nine species now known from this group. None of the freshwater molluscs were new. All the new species will be described in the 'Annals and Magazine of Natural History.'

2. *On the Peculiarities of the Avifauna of the Canary Islands. By the* Rev. Canon H. B. Tristram, *F.R.S.*

The seven islands which form the Canary group naturally divide themselves into two groups. 1st. Lanzarote and Fuertaventura, those nearest the African continent, and which may be looked upon as insular outliers of the Sahara. 2nd. The other five islands, Canaria, Tenerife, Gomera, Palma, and Hierro. The first group are slightly elevated plateaux with a completely surrounding fringe of low volcanic hills, and are destitute of timber and almost of water. The birds are all identical with or closely allied to those of the Sahara, notably, *Otis houbara, Pterocles arenarius, Cursorius gallicus, Pyrrhula githaginea, Calandrella minor, Parus ultramarinus* var. Only one peculiar species has been found—*Pratincola dacotiæ.* The only peculiar Canarian species which occurs is *Anthus bertheloti.* The second group are much more varied in their avifauna. In only three of them, Tenerife, Gomera, and Palma, is there any extent of natural forest. This extends generally from 3,500 feet above the sea level to 5,000 feet. Only in these forests are most of the peculiar species found, especially the two species of pigeon—*Columba laurivora* and *C. bollii*—the former in two, the latter in all three of the forested islands. Their distinctive habits are described. Of the Chaffinches there are three species; one, *Fringilla tintillon,* found in Canaria, Tenerife, and Gomera. Another, *Fr. teydea,* peculiar to Tenerife; and a third, *Fr. palmæ,* peculiar to Palma. The Titmouse of three islands is *Parus teneriffæ,* which can always be discriminated from *P. ultramarinus.* In Palma is a third very distinct species, *Parus palmensis.* The only peculiar bird which seems common to all seven islands is *Anthus bertheloti.* In Canaria *Caccabis rufa* is common, in Tenerife and Gomera *C. petrosa* takes its place. In Palma there is no Partridge. Quail are found in all the islands. The Cornish Chough abounds in Palma, to which it is exclusively confined. The Woodcock is a permanent resident in three of the islands. The peculiarities of the forests are described, and the paper endeavours to show the connection of the variation of the avifauna with the geological history of the group.

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3. *On* Syrrhaptes paradoxus *as a Native of Britain. By* Professor A. Newton, *M.A., F.R.S.*

On two previous occasions (1863 and 1883) the author had brought the irruptions of this singular bird before the Association; he now had to speak of it as a native, and exhibited a specimen, not more than two or three days old, which had been captured in the North of Scotland on the 8th of August last; and was, so far as he knew, the first that had been seen by any scientific ornithologist.

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4. *On the Morphology of the long flexors of the digits of the Mammalian Hand. By* Professor B. C. A. Windle.

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5. *On certain Congenital Abnormalities in Fishes. By* Professor B. C. A. Windle.

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6. *On the Cæca of a Tinamou. By* Frank E. Beddard, *M.A.*

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7. *Contributions to our Knowledge of the Freshwater Annelids. By* Frank E. Beddard, *M.A.*

In spite of the labours of Claparède, D'Udekem, Perrier, Vejdovsky and Stolç upon the Continent, and of Lankester, McIntosh, Bousfield and others in this country, a good deal remains to be done before we can claim to have a satisfactory knowledge of even the British freshwater Oligochæta, while the exotic forms,

except those studied by Leidy and Eisen in America, are at present almost entirely unknown. Having lately had the opportunity of studying some New Zealand 'Limicolæ,' through the kindness of Mr. W. W. Smith of Ashburton, I beg leave to offer the following remarks upon them, and also upon some little known British species.

I have received from Mr. Smith numerous examples of *Tubifex*, *Limnodrilus* and *Phreoryctes*; hence it appears that the general facies of the New Zealand oligochætous fauna is not widely different from that of Europe. Indeed the two former species seem to me to be identical with those which occur in this country. With regard to *Phreoryctes* I have already ('Ann. and Mag. Nat. Hist.' 1888,) described the principal facts in the anatomy of the New Zealand species; since that time a fresh consignment of specimens has arrived which enables me to add some details bearing upon its relations to other genera.

Phreoryctes is one of those genera which break down the older distinction between the '*Oligochæta terricolæ*' and the '*Oligochæta limicolæ*'; and the New Zealand species (which I have named *P. Smithii*) is more thoroughly intermediate in its characters than either of the two European forms. It agrees with many earthworms in having paired setæ, two pairs of testes and of vasa deferentia without atria; but the characters of the seminal sacs, the egg sacs, and the ova (large with abundant yolk) ally it to the lower Oligochæta. I find that the clitellum occupies four segments (Nos. 10–13), and that there are no specially modified genital setæ present. A paper dealing with the general anatomy of this worm will shortly appear in the 'Transactions' of the Royal Society of Edinburgh.

Another Oligochæt, which I have recently investigated, is the little-known form *Æolosoma*. The following species are now known to occur in the British Islands:—*Æ. quaternarium* (Ehrbg.), *Æ. Ehrenberghii* (Œrsted), *Æ. variegatum* (Vejd.), *Æ. tenebrarum* (Vejd.), and *Æ. Headleyi* (Beddard). The last two species I have myself added to the British fauna, while some specimens of *Æ. variegatum* were kindly sent to me by Professor Hartog, from Cork.

One peculiarity of this genus is the presence of coloured fatty globules in some of the epidermic cells; these globules are brownish-yellow in *Æ. quaternarium* and *Æ. Ehrenberghii*, greenish-yellow in *Æ. tenebrarum*, bright-green in *Æ. variegatum*, bright-green to bluish-green in *Æ. Headleyi*. The pigment, which may be perhaps one of the 'lipochromes' of Krukenberg, is in every case changed to violet by the action of alkalies.

The sexual organs of the genus *Dero* have not yet been described, although, thanks to the investigations of Perrier ('Arch. de Zool. Expt. I.,' 1872) and of Bousfield ('Journ. Linn. Soc.,' 1887), the general anatomy of this Annelid is well known. These researches, as well as others made previously, tend to prove that *Dero* is a near ally of *Nais*.

I find that the clitellum in the sexually mature worm occupies segments 5–7 (inclusive); there is no special modification of any of the setæ in the neighbourhood of the sexual orifices such as occurs in *Nais*, but the ventral setæ of segment 6, on to which the atria open, are entirely absent.

There is a single pair of pyriform spermathecæ opening close to the border line between segments 4 and 5, the pouches themselves being in the latter segment.

The atria, as already mentioned, open upon the 6th segment; the seminal sac is large, and extends back as far as the 8th segment; it is furnished with a pair of contractile blood-vessels.

The ripe ova, which are very few in number (2–4), occupy segments 9 and 10.

It will be obvious from the above description that there are no great differences between *Dero* and *Nais* in the sexual organs.

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8. *Note on the Tarpon.* *By* Professor McIntosh, *M.D., F.R.S.*

A specimen, kindly sent by Lady Playfair, and measuring six feet in length, was exhibited, and remarks made on its structure and habits.

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9. *On the larval and post-larval stages of the Sole and other Food-Fishes. By* Professor McIntosh, *M.D., F.R.S.*

The peculiar structure of the ovum of the sole, which has also been described by Raffaele and J. T. Cunningham, was alluded to at the commencement. It was further mentioned how easily the ova had been hatched at St. Andrews, in contradistinction to the difficulties hitherto experienced elsewhere. The remarkable coloration of the larval sole is diagnostic. Both body and fins are minutely speckled with stone-coloured pigment, so that it is very readily seen in the water. As it gets older this hue vanishes, and a general ochreous tint takes its place. The structure of the head, position of the eyes (both being visible from the front, and used by the animal for anterior vision), structure of the fins and other parts, were next examined. The changes in the position of the oil-globules during the earlier stages of development and after absorption of the yolk were also noticed. It was stated that the larval and post-larval soles were amongst the hardiest and most active young fishes, and that no difficulty would be experienced in increasing this fish by artificial means. Amongst other forms the larval and post-larval sprat were described, and the differences between this species and the herring indicated.

10. *Notes on new and rare Forms at the St. Andrews Marine Laboratory. By* Professor McIntosh, *M.D., F.R.S.*

A peculiar change occurring in *Lesueuria vitrea* (a form first clearly described as British last year) was noted. This consists of the great enlargement in many examples of the mouth-lobes, so that the general aspect resembles that of *Lesueuria hyboptera* of Alex. Agassiz. For the first time a Heteropod (*Atlanta*) was intimated as an inhabitant of the British seas; *Actinotrocha*, the remarkable larval stage of *Phoronis* (a borer in calcareous rocks, &c.) was mentioned as being common in autumn, while the *Arachnactis*-stage of *Edwardsia*, in contrast to the condition in the Zetlandic waters, was rare and minute. The use of the various nets (bottom, mid-water, and surface) systematically throughout the year in connection with fisheries' work demonstrated the continued presence of many types hitherto supposed to be occasional and rare visitants.

Botanical Department.

1. *The Occurrence of* Arenaria norvegica *in Yorkshire. By* J. G. Baker, *F.R.S.*

2. *The Meristern of Ferns as a Study in Phylogeny. By* Professor F. O. Bower, *F.L.S.*

3. *The Structure of the Nucleus in* Saprolegnia. *By* Professor M. M. Hartog, *D.Sc.*

4. *Observations on the Structure of the Nuclei in* Peronospora, *and on their behaviour during the formation of the Oosphere. By* Harold W. T. Wager.

The various organs of *peronospora parasitica*, the mycelium, antheridia, oogonia, and conidia, contain numerous deeply-staining nuclei, which in very thin sections, obtained by means of a ribbon section-cutting microtome, and stained in a very

dilute solution of Kleinenberg's hæmatoxyline, exhibit a very distinct nuclear structure.

The division of the nucleus takes place by a process of karyokinesis, comparable to that which takes place in the division of the nucleus in the higher plants. This can be most satisfactorily observed in the nuclei of the oogonia.

The nuclei of the oogonium at an early stage in the development of the latter are spherical or slightly oval, vesicular bodies, each of which contains a large mass of chromatin, forming a peripheral layer on its wall.

All the nuclei of the oogonium divide, and the process of division is accompanied by changes in the protoplasm, leading to the formation of the oosphere. These changes are more complicated than is generally supposed.

The protoplasm of the oogonium at an early stage appears to be a homogeneous, granular mass containing numerous nuclei, as described above.

Numerous vacuoles appear in the centre of the oogonium, causing the greater part of the protoplasm and all the nuclei to be restricted to the periphery, leaving in the centre a space, about equal in size to the future oosphere, containing a small central mass of protoplasm, connected to the parietal layer by protoplasmic strands. At the same time the nuclei swell up, and exhibit a thread-like structure. They become arranged very regularly, and form a single layer in the parietal protoplasm.

The chromatic threads next arrange themselves in the equatorial plane of the nucleus, and then divide into two groups of threads, each of which forms a daughter nucleus.

The daughter nuclei again divide, and then two or perhaps more pass towards the centre of the oogonium, and soon afterwards the cell wall of the oosphere begins to form on the inner side of the parietal layer of protoplasm, leaving this, together with the remainder of the nuclei outside, to form the periplasm.

From this mass of protoplasm and nuclei both the endosporium and the exosporium are formed.

One or more antheridia are developed in connection with the oogonium. Each contains several nuclei, which divide up in the same manner and at the same time as those in the oogonium. The antheridia send out fertilising tubes, swollen at the ends, which pass to one side of the oosphere, come into close contact with it, and appear to open into it by a small aperture. The passage of a nucleus from the antheridium into the oosphere has not been directly observed, but it is probable that fertilisation does take place, as two nuclei have been seen in the oosphere at about the time when a nucleus or nuclei from the antheridium appear to pass over into the fertilising tube, and at a later stage one nucleus only is seen.

The nuclei of the mycelium divide in a similar manner to those in the oogonium, but they do not become so large nor exhibit the details so clearly.

The conidia or zoosporangia contain numerous nuclei, differing in structure from the nuclei in the other parts of the fungus. They consist of a central mass of chromatin, surrounded by a layer of nucleoplasm, with a firm outline. They are spherical or slightly oval bodies, a little larger than the nuclei of the mycelium.

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5. *The Antherozoids of Cryptogams.*
By Alfred W. Bennett, *M.A.*, *B.Sc.*, *F.L.S.*

The object of this paper was to bring out the difference between the two modes in which the ciliated fertilising organs of Cryptogams are formed, the first type being that which occurs in Vascular Cryptogams, Muscineæ, and Characeæ, the second in Algæ (excluding Characeæ).

The essential character of the first type is that the antherozoid is formed from the nucleus only of its mother-cell; the whole of the rest of its protoplasm being consumed in the development of the antherozoid. The vibratile cilia which give to the mature antherozoid its power of rapid movement proceed from a peripheral layer of hyaline protoplasm belonging to the nucleus. In Ferns and other Vascular Cryptogams these cilia are very numerous, forming a tuft attached to the

anterior end of the antherozoid. The antherozoids of Muscineæ (Musci and Hepaticæ), and those of Characeæ, have only two very long and slender cilia attached in the same position. The structure and mode of development of these organs are almost identical in these two classes.

In the Fucaceæ, on the other hand, which may be taken as the highest type of Algæ with ciliated antherozoids, the structure of the antherozoid is altogether different. It is a naked cell, not enclosed in a cellulose-wall, with cytoplasm, nucleus, and pigment-spot; the two cilia both spring from a spot in close proximity to the eye-spot, although one of them is attached to the body of the antherozoid for a portion of its length.

The paper was illustrated by diagrams taken from the beautiful work on the 'Development and Structure of Antherozoids,' by M. L. Guignard; and the importance of the above facts was pointed out in support of the view that the Characeæ are more nearly related to the Muscineæ than to the true Algæ.

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6. *A Hybrid Desmid.* *By* ALFRED W. BENNETT, *M.A.*, *B.Sc.*, *F.L.S.*

The author described the occurrence of what he regards as a hybrid form between *Euastrum crassum*, Ktz. and *E. humerosum*, Ralfs.

FRIDAY, SEPTEMBER 13.

The following Papers and Reports were read:—

1. *Discussion on Acquired Characters.*

(a) *On the supposed Transmission of Acquired Characters.* *By* E. B. POULTON, *F.R.S.*

(b) *Feasible Experiments on the Possibility of transmitting Acquired Habits by means of Inheritance.* *By* FRANCIS GALTON, *F.R.S.*

Feasible experiments have yet to be designed that shall be accepted as crucial tests of the possibility of a parent transmitting a *congenital* aptitude to his children, which he himself possessed, *not congenitally*, but merely through long and distasteful practice under some sort of compulsion.

The requirements are to eliminate all possibility of parental or social teaching, to bring up all the descendants in the same way, to make simultaneous experiments on many broods during many generations, and, lastly, to economise time, money, and labour. This list of requirements points with emphasis to experimenting on creatures that are reared from eggs, as fowls, fishes, and moths. *Fowls*—The largely extending practice of hatching eggs in incubators for commercial purposes, and the varied aptitudes of poultry, make them very suitable subjects. Birds are said to have an instinctive dread of various insects; hence mimetic insects, that are really good for food, are avoided by them. Do such insects exist, and could they be easily reared, which poultry would avoid at first, though experience would soon teach them to like and to eat greedily? Similarly as regards sounds and cries, which would frighten at first, but afterwards be welcomed as signals for food, &c. Would the stocks of two breeders, one of whom adopted such experiments as these and the other did not, differ in instinct after many generations? *Fish*—The experiment (quoted by Darwin) of Mobius with the pike, using a trough of water divided by a glass plate into two compartments, in one of which was the pike and in the other were minnows, was mentioned as an example. The pike after dashing at the minnows many times, and each time being checked and hurt by the glass plate, during some weeks, finally abandoned all attempts to seize them, so that when the plate was removed the pike never afterwards ventured to attack

the minnows. The question, then, is, whether fish reared for some generations under conditions which compelled them to adopt habits not conformable to their natures would show any corresponding change of instinct. Of course each generation would be reared in a separate tank from its parents. *Moths*—Experiments have been made for the author by Mr. Frederic Merrifield with the *Selenia Illustraria*, which has two broods yearly. They are being made for quite another purpose, but have already shown the ease of breeding hardy moths on a large scale when the art of doing so is well understood. All larvæ are fastidious in their diet, but it may well be that certain food which they would not touch at first would after a while be greedily eaten, and be found perfectly wholesome.

Experiments on the lines here suggested ought to show the proportion of cases in which acquired aptitudes of several kinds are *certainly not* inherited. They might also, perhaps, show that in a small proportion of cases they *certainly are*. Thus limits would be fixed within which doubt remained permissible. The object of this paper is to invite experts to discuss the details of the most appropriate experiments for doing this.

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2. *The Palæontological Evidence for the Transmission of Acquired Characters.* *By* Professor HENRY F. OSBORN.

As a contribution to the present discussion upon the inheritance of acquired characters I offer an outline of the opinions prevailing among American naturalists of the so-called Neo-Lamarckian school, and especially desire to direct attention to the character of the evidence for these opinions. This evidence is of a different order from that discussed in Weismann's essays upon 'Heredity,' and while it cannot be said to conclusively demonstrate the truth of the *Lamarckian principle*, it certainly admits of no other interpretation at present, and lends the support of direct observation to some of the weightiest theoretical difficulties in the pure *Selection principle*.

1. We regard natural selection as a universal principle, explaining the 'survival of the fittest' individuals and natural groups, and as the only explanation which can be offered of the origin of one large class of useful and adaptive characters. We supplement this by the Lamarckian principle as explaining the 'origin of the fittest' in so far as fitness includes those race variations which correspond to the modifications in the individual springing from internal reactions to the influences of environment. There is naturally a diversity of opinion as to how far each of these principles is operative, not that they conflict.

2. If both principles operate upon the origin of the fittest we should find in every individual two classes of variation, both in respect to new characters and to modifications of the old: *First, chance variations*, or those which, with Darwin and Weismann, we attribute to the mixture of two diverse hereditary strains; these may or may not be useful; if useful they depend entirely upon selection for their preservation. *Second, variations which follow from their incipient stages a certain definite direction towards adaptation*; these are not useful at the start; thus while, as they accumulate, they favour the individual, they are not directly dependent upon selection for their preservation; these we attribute to the Lamarckian principle.

My present purpose is to show that variations of the second class are of an extent and importance not suspected previous to our recent palæontological discoveries, and that the Lamarckian principle offers the only adequate explanation for them.

3. The general theory as to the introduction and transmission of variations of the second class may be stated as based upon the data of palæontology—the evolution of the skeleton and teeth.

(1) In the life of the individual, adaptation is increased by local and general metatrophic changes, of necessity correlated, which take place most rapidly in the regions of least perfect adaptation, since here the reactions are greatest. (2) The main trend of variation is determined not by the transmission of the full adaptive modifications themselves, as Lamarck supposed, but of the disposition to adaptive

atrophy or hypertrophy at certain points. (3) The variations thus arising are accumulated by the selection of the individuals in which they are most marked and by the extinction of inadaptive natural groups. Selection, in so far as it affects these variations, is not of single characters but of the *ensemble* of characters.

The evidence is of a direct and indirect character. The direct evidence is that by actual observation in complete palæontological series, the origin of adaptive structures is found to conform strictly to the lines of use and disuse. The indirect proof is that the natural selection of chance variations is unsupported by observation and is inadequate to explain the variation phenomena of the second class.

4. I will first briefly consider the former. The distinctive feature of *palæontological evidence* is that it covers the entire pedigree of variations, *the rise of useful structures not only from their minute*, apparently useless, condition, but from the period before they appear. The teeth of the mammalia render us the most direct service, as compared with the feet, since they furnish not only the most interesting correlations and readjustments, but the successive addition of new elements. With a few exceptions which need not be noted here, all the mammalia started with teeth of the simple conical type—like the simple cusps of reptiles. Practically every stage between this single cusp and the elaborate multicusped recent molars is now known. Every one of the six main cusps of the molar of *Hyracotherium*, for example, a type of an important central stage in the ungulate dentition, is first indicated at the first point of contact or extreme wear between the upper and lower molars; this point of wear is replaced by a minute tubercle, which grows into a prominent cusp. These are the laws of cusp-development, as observed in every known phylum of mammalia:—

I. The primary cusps first appear as cuspules, or minute cones, at the first points of contact between the upper and lower molars in the vertical motions of the jaws.

II. The modelling of cusps into new forms, and the acquisition of secondary position, is a concomitant of interference in the horizontal motions of the jaws.

5. The evidence, of which this is only a single illustration, has accumulated very slowly. The line of reasoning from this particular series of observations is as follows:—1. The new main variations, in the teeth and skeleton of every complete series, are observed to follow certain definite purposive lines. 2. By careful analysis of the reactions to environment which would occur in the individuals by the laws of growth—we observe that the race variations strictly conform to the line of these reactions. 3. We further observe that no variations of this class occur without the antecedent operation of these reactions; the working hypothesis thus stands the test of prediction. 4. We accept this invariable sequence of race adaptation upon individual adaptation as proof of a causal relationship.

6. I admit that this proof may be invalidated in several ways:—1. By showing in more extended research that these observations of sequence are inaccurate or offset by others in which there is no such sequence. 2. By showing that the Lamarckian principle, while explaining some of the variations of this class, is directly contradictory to others. 3. By showing that all these phenomena may be explained equally well or better by natural selection. 4. By proving, independently, that the transmission of acquired characters never occurs.

I will now consider each of these cases:—

1. *As regards these observations.*—They may be examined in detail in the studies of Cope, Wortman, or Ryder, and in a paper I presented to this Association last year. As the question of transmission has been generally assumed in the foregoing studies, I think it is now important to review the whole field, searching for facts which look against the Lamarckian principle; for as we have been hitherto studying with a *bias* in favour of it, some such adverse points may have been overlooked. At present, however, I can recall only a single adverse observation, that is, in the development of one of the upper cusps, the lower cusp which opposes it, and which is therefore supposed to stimulate this development, is found to recede. I have no doubt others will be found presenting similar difficulties.

2. *As regards the Lamarckian principle.*—Several objections to the special

application of this principle to the evolution of the teeth have been raised by Mr. E. B. Poulton :—

A. To the objection that the teeth are entirely formed before piercing the gum, and that use produces an actual loss of tissue as contrasted with the growth of bone, it may be said that by our theory, it is not the growth itself, but the reactions which produce this growth in the living tissue, which we suppose to be transmitted.

B. To the objection that this proves too much, that the cusps thus formed would keep on growing, it may be said (*a*) that in the organism itself these reactions occur least in the best adapted structures. This proposition is difficult to demonstrate in the case of the teeth, but may be readily demonstrated in what are known as the phenomena of displacement in the carpals and tarsals where growth has a direct ratio to impact and strain. (*b*) In the organism itself growth does not take place beyond the limits of adaptation; there is, therefore, no ground for the supposition that overgrowth will take place by transmission. (*c*) Either by the selection or Lamarckian theory development, is held in check by competition between the parts; there is a limit to the nutritive supply; in the teeth, as elsewhere, the hypertrophy of one part necessitates atrophy of another.

C. A general objection of considerable force is that we find other adaptations, equally perfect, in which the Lamarckian principle does not apply; why then invoke it here? To this it may be said that there is no theoretical difficulty in supposing that while natural selection is operating directly upon variations of the first class, the Lamarckian principle is producing variations of the second class, and while selection does explain the former, it falls far short of explaining the latter.

D. Finally, if Weismann succeeds in invalidating the supposed proofs of the Lamarckian principle derived from pathology and mutilations, this will not affect the argument from palæontology and comparative anatomy, for these proofs involve two elements which are not in our theorem: (*a*) immediate transmission of characters; (*b*) transmission of characters impressed upon the organism and not self-acquired.

3. *As regards the adequacy of the Selection principle to explain these variation-phenomena.*—It is not necessary to repeat here the well-known current theoretical objections to this principle, but simply to point out the bearing of this palæontological evidence. In Weismann's variation theory the preponderating influence must be conservative, however it may explain progressive modification, or even correlation of old characters, it does not admit that the genesis of new characters should follow definite lines of adaptations which are not pre-existent in the germ plasma. We find that new characters of the second class do follow such purposive or directive lines, arising simultaneously in all parts of the organism, and first appearing in such minute form that we have no reason to suppose that they can be acted upon by selection. The old view of nature's choice between two single characters, one adaptive, the other not adaptive, must be abandoned, since the latter do not exist in the second class.

4. *The most serious obstacle to the Lamarckian principle is the problem of transmission.*—How can peripheral influences be transmitted in the way we have outlined—now that we have such strong evidence for the continuity of the germ plasma? If acquired characters are not transmitted, it is clear that the whole Lamarckian principle is undermined, and all these instances of sequence express no causal relationship. We are then, however, left without any adequate explanation of the laws of variations of the second class, and are thus driven to postulate some third, as yet unknown, factor in evolution to replace the Lamarckian principle.

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3. *Report of the Committee for improving and experimenting with a Deep-sea Tow-net for opening and closing under water.*—See Reports, p. 111.

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4. *An improved form of Deep-sea Tow-net.* By G. C. BOURNE, *M.A.*

At the last meeting of the British Association Mr. Hoyle exhibited an apparatus for opening and closing a tow-net at any considerable depth below the surface of the water. Ingenious as this device was, it appeared to be defective in one important point—that it depended on the use of the 'traveller,' which is uncertain in its action when any length of line is used, because of the curvature that is necessarily present in a line trailing behind a boat in motion, and also is unsuitable for use with anything but a steel or phosphor-bronze wire rope, and is even untrustworthy when either of these is in use, because it is stopped by any kinks, such as are certain to occur in a well-used rope.

In seeking for a better device for opening and closing a tow-net beneath the water, I was informed of an ingenious instrument invented by Mr. Petersen, the engineer at the Naples Zoological Station; but this again was defective in construction, as the revolving screw, which forms the essential part of his instrument, is liable to become jammed through the strain put upon it by the fastening adopted for the tow-net.

The instrument which I now describe is a modification and improvement of Petersen's, and was designed for me by Lieut. E. Warre Slade, R.N., to whose design I have added only a few trifling modifications.

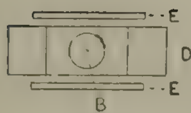
The tow-net is fitted by its mouth to a frame of galvanised iron. This frame consists of two smaller half-hoops, Y (represented as closed in the diagram), which are hinged together so as to form a circular mouth when open. To these the tow-net itself is attached. In addition to these, there is a single and larger half-hoop X. It is obvious that if the tow-net is pulled through the water by the cords G attached to the half-hoop X, the pressure of the water will force apart the two half-hoops Y, and if the cords H attached to the latter are slack, the tow-net will be towed mouth open.

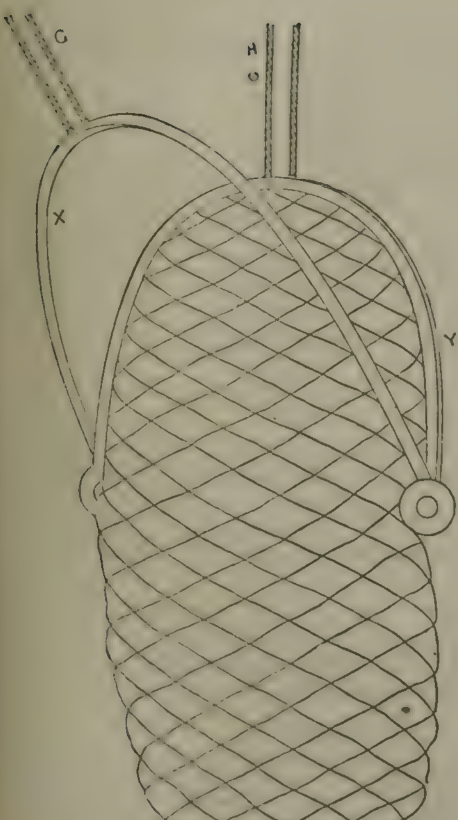
On the other hand, if G is slacked, and the tow-net is pulled by the cords H attached to each of the half-hoops Y, the tow-net will be pulled along mouth closed.

So far the arrangement is identical with that adopted both by Mr. Hoyle and Petersen.

The apparatus for alternately slackening and pulling upon the cords H and G, so that the tow-net may be closed, opened, and closed again, consists of a brass frame, A A, to the ring at the front end of which the tow-net is made fast. B B is a screw-shaft occupying the centre of the frame, and revolving in bearings at the bottom of the frame and in the cross-piece towards the top of the frame. To the upper end of this screw-shaft the fan C is attached. D is a block through which the screw-shaft passes, and is kept in position by the guides E E. As the guides can only be shown in outline in the figure, a section of the screw-shaft with the guides and block is given on the left hand of the diagram, to show their relations to one another. If the screw-shaft is revolved, the block, being prevented from turning round by the guides, must travel up or down the screw, according as the latter is turned in one direction or the other. At *g g* and *f f* are tumbling-hooks and catches, the catches being of such a length that they are lifted by the block D as the latter travels up the screw. The cords G G and F F are fastened to the tumbling-hooks *g g* and *f f* by rings. The cords G G are fastened to the half-hoop X of the tow-net. The cords F F, when they are fastened in the tumbling-hooks *f f*, pull on the cords H H attached to the half-hoops Y of the tow-net, but when they are freed from the tumbling-hooks the cords J J support the cords H H, and F F lie slack. The lengths of the cords G G and F F (which should be made of wire, to avoid stretching) are so regulated that when both are fixed in their proper tumbling-hooks, the tow-net is supported entirely by F F, but when these are released the tow-net is supported entirely by the cords G G; J J remaining slack until G G are in turn released.

When the tow-net is required for use the screw is turned round till the block D is at the bottom of the frame, the cords G G, F F, are fastened to their proper tumbling-hooks, and the catches of the latter are firmly pressed home. The


E
D
E
B


G
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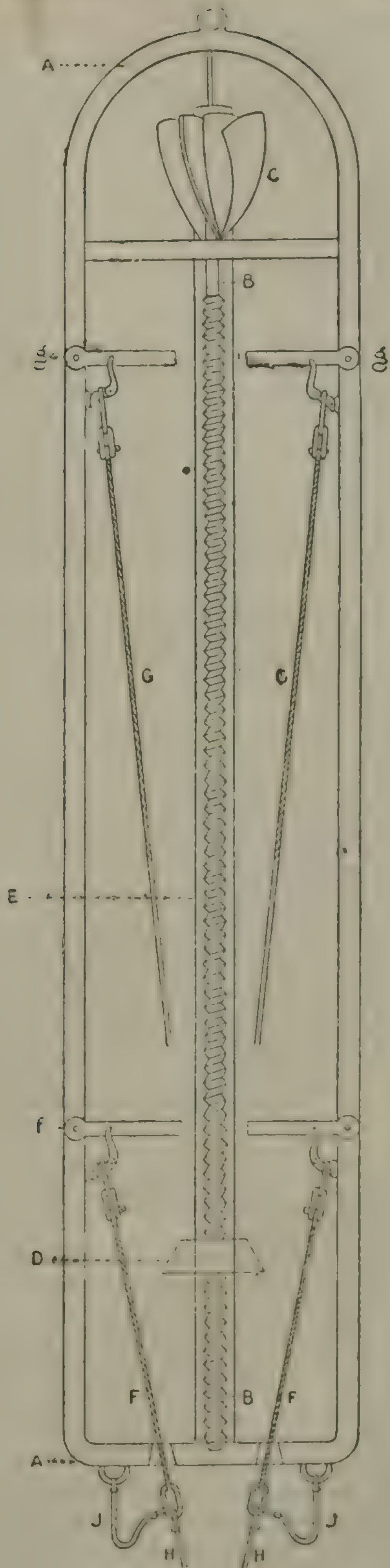
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J

apparatus with the tow-net attached is then thrown overboard, sunk by a suitable weight to the required depth, or is attached to the road of a trawl, and is towed behind the boat. As it moves through the water the fan C revolves, and causes the block D to ascend the screw. At first the tow-net is supported entirely by the cords F F, which, being fastened through H to the two half-hoops Y, keep the mouth of the tow-net closed. But when the block D arrives at the catches of the tumbling-hooks *f*, it knocks them up, the tumbling-hooks fall down, freeing the cords F F, and then the tow-net is pulled along by the cords G G attached to the half-hoop X. The tow-net then opens, and remains open, whilst the block D is travelling from *f f* to *g g*. On arriving at the catches of the tumbling-hooks *g g*, the block in turn knocks these up and frees the cords G G. Now the whole weight of the tow-net is thrown on the cords H H, carried by J J; the mouth of the tow-net therefore closes.

In this form of apparatus the length of time for which the tow-net will remain open depends upon the pitch of the blades of the fan, the thread of the screw, and the length between *g g* and *f f*. Thus if the pitch of the fan be 50″, and the threads in the screw 18 to the inch, the block will move one inch for every 10–12 fathoms traversed. If the ship moves at two knots per hour, and the distance between *g g* and *f f* is 14 inches, the tow-net will remain open for about $5\frac{1}{2}$ minutes; but by reducing the thread of the screw, and lengthening the distance between *g g* and *f f*, this time could be very considerably increased.

5. *Third Report of the Committee for taking steps for the establishment of a Botanical Station at Peradeniya, Ceylon.*—See Reports, p. 114.

6. *On the Shape of the Oak-leaf. By* Sir JOHN LUBBOCK, *Bart., F.R.S.*

We are so accustomed to the form of the oak-leaf that it does not strike us as anything peculiar, and comparatively few perhaps have ever asked themselves why it should be as it is.

And yet it is peculiar, unlike that of any of our forest trees, and those of the evergreen oaks so abundant in hotter countries.

In botanical phraseology they are 'deciduous, oblong-oblanceolate, or oblong-elliptical, sinuated, with blunt lobes extending not more than half-way down to the mid-rib.' The sinus between the lobes is generally rounded off at the bottom.

Again, though I have not found this mentioned in the botanical works which I have consulted, they are rarely symmetrical, the lobes of the two sides not corresponding.

The three points, then, which give the oak-leaf its peculiar form are:—

1. The deep, rounded sinuses.
2. The want of symmetry of the two sides.
3. The oblong or oblanceolate outline.

I do not know of any attempt to explain this peculiar form. As regards the sinuses, Kerner suggests that they are intended to permit the passage of light to the lower leaves.

I would not deny that the space between the lobes may be of some advantage in the manner suggested by Kerner, but I greatly doubt whether this is the main or primary explanation.

That which I would suggest is as follows. The leaves of the evergreen oaks are entire, and small in comparison with those of the English oak. During the winter and early spring they are protected by a series of brown scales, inside which they lie, and with which they form the well-known buds which are so familiar to us, and which are both small and short in proportion to the size of the leaves themselves.

In cooler and moister regions, on the contrary, there is, as we know, a tendency for leaves to become larger and deciduous. I will not now enter into the reasons for this, but the fact will not probably be denied. These influences do not, how-

ever, affect the outer scales, which remain as before without any increase of size. But as the leaves have increased in size and the buds have not, the leaves can no longer retain their original arrangement in the bud. If, for instance, we compare the buds of the oak and of the beech we see that while the leaf of the oak is longer than that of the beech, the bud of the oak is, on the contrary, shorter than that of the beech.

Under these circumstances what must happen? The leaf grows and becomes longer than the bud; it is therefore necessarily bent into a curve. But an entire leaf, if thus thrown into a curve, would necessarily fall into folds, the number being determined by the number of ribs or veins. For such folds, however, there would be no room within the narrow limits of a bud, or rather perhaps they would be inconvenient because they would leave more or less empty spaces.

This may be rendered more clear by taking a piece of cloth or paper, folding it up, and then throwing it into a curve. It will then necessarily fall into one or more folds. If it were strengthened, as an oak leaf is, by three or four side-ribs, there would be a fold between each two ribs. As a matter of fact, however, from the absence of space the membrane where the fold would be is not actually developed. We may imitate this by removing them. If this be done the result will be the formation of sinuses, rounded at the base, closely resembling those so characteristic of the oak leaf. These sinuses are due then, as I believe, to the curvature of the leaf, owing to the shortness of the bud in comparison with the length of the leaf.

The young leaf is not only curved, it is wrapped round the interior leaves. The result of this is that one side of the leaf is folded within the other; the one therefore being on the outside has more space than the other. The two sides of the leaf are in fact differently situated, and this I believe accounts for the second point—namely, the want of symmetry.

The oblong form is an advantage from the way the leaves diverge from the stalk.

In this manner the interesting peculiarities of the oak leaf may be accounted for.

The paper was illustrated by diagrams, specimens, and models, and the probability of the cause suggested being the true one was enforced by the application of a similar argument, which clearly explains the peculiar form assumed by the very interesting and curious leaves of the tulip-tree.

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7. *On the Leaves of the Guelder Rose. By* Sir JOHN LUBBOCK, *Bart., F.R.S.*

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8. *On the Modifications of Electric Organs in Elasmobranch Fishes. By* Professor J. COSSAR EWART, *M.D.*

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9. *Observations on the Migration of Fishes. By* Prof. J. COSSAR EWART, *M.D.*

SATURDAY, SEPTEMBER 14.

The Section did not meet.

MONDAY, SEPTEMBER 16.

The following Papers were read :—

1. *Specific Characters as useful and indifferent. By* Professor G. J. ROMANES, *F.R.S.*

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2. *The Limit between the Continental and Abyssal Marine Fauna. By the* Rev. Canon NORMAN, *M.A., D.C.L.*

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3. *The Secretion of Silk by the Silkworm. By* Professor GUSTAVE GILSON.

The silk is produced in a special apparatus communicating with a short tube, which lies on the lower lip of the worm. The silk-producing glands consist of two tubes rolled up under the digestive organs. Both unite in the anterior part of the body into one single tube, the common silk-duct. Not far from their point of union these tubes receive the excretory canal of two accessory glands.

The common silk-duct opens at the end of the spinning-tube on the lip. A peculiar apparatus, whose structure and function I shall describe later, is to be found in the middle part of this duct. The two glandular tubes are composed of large polygonal cells containing a ramified nucleus. The silk appears as a transparent cylinder of a half-solid and viscous substance, filling the tube. The worm stretches out this substance into a thread, which dries up when it reaches the air, and becomes very hard.

The two silk streams which leave the two glands do not mix into a single one. They simply unite in the common duct, and become glued together by a sticky matter, which is probably produced by the accessory glands. In this manner the silk thread of which the cocoon is made up is a flat string composed of two united threads.

The silk is, without doubt, produced by the large cells that compose the walls of the gland. But the question is, *how do these latter work* to fill the interior of the tube with the silk substance? and this is the point to which I have especially applied myself.

When one makes a section through the gland the silk appears as lying close to the inner surface of the cells. But such sections do not explain at all the process of the excretion of the silk. This half-solid substance, which is harder than the substance of the cell, might be either a regular secretion-product or a result of the total transformation of the protoplasm. It is now pointed out, indeed, that certain solid or glutinous substances constituting the membrane of many kinds of cells take their origin by such a transformation proceeding layer by layer. In fact the question was not so easy to explain as it might appear. However, I have now arrived at the conviction that the silk is a regular secretion-product.

I will give a short account of the observations that have induced me to form this conclusion. In the first place the glandular tube is internally covered, on its whole length, by a transparent membrane. This membrane is very thin and not easily detected. It contains circular threads, and the spaces between them are filled with a network-formation. It appears to be very hard and consistent. During the metamorphosis of the caterpillar, when the cells are degenerating, it remains visible later than the cells themselves. The silk, being then always divided from the cells by a membrane, cannot be a result of the direct transformation of the protoplasm.

Secondly. The silk is, in fact, ordinarily not to be detected by any reagents in the body of the cell, and that was just another support to the hypothesis of the total transformation of the protoplasm into silk-substance. But in some cases the silk becomes really visible within the body of the cell. At the end of larval life, especially in other species than the common silk-worm, I have found in the cells certain shining spherules whose reactions were just the same as those of the silk.

But further indications have been furnished to me by some experiments I have made.

If one impedes the excretion of the silk, at the end of larval life, the cell still continues to produce silk, and this silk becomes accumulated within the protoplasm. The cell-body becomes quite burdened with silk-spherules. But it was not easy to put a stop to the excretion of the silk. I did not succeed in making a vivisection and tying the gland itself, because it was not possible to preserve the wound against the microbes, and the animal always soon died.

I have sometimes succeeded in stopping the tube on the lip with collodion; but the best way was always to tie strongly the whole body of the caterpillar at one of the anterior segments. I have kept caterpillars tied in this manner alive for months. Several larvæ of *Bombyx rubi* tied in four places and sectioned between two ligaments have remained alive for three months, and several of these separated segments underwent the first stages of metamorphosis. The caudal segment was always the last survivor.

We may thus admit that the silk is made up within the protoplasm and cast out through the meshes of the net-like membrane. A selection is made probably by this membrane itself amongst the several substances that are mixed with the liquid part of the protoplasm and the silk, or the substance that becomes the silk is cast out. Possibly in the normal animal this substance acquires the qualities of the silk only when it has reached the interior of the gland, but in the tied animal it becomes real silk-substance in the cell itself.

Now, with regard to the special apparatus of the common silk-duct. A transverse section through it, as seen under a sufficient enlargement, shows that it is a pressing engine. It consists of a chitinous cylinder with a strong and highly elastic wall. The upper part of this wall presents a ridge projecting into the tube and pressing upon the two connected silk threads. Powerful muscles are attached in such a way that their action is opposed to the elasticity of the walls. So their contraction causes the bore of the tube to be enlarged and the silk to be less compressed by the ridge.

The use of this apparatus seems to be:—

1st. To regulate the diameter of the thread, which is often very irregular before it has passed through it.

2nd. Probably to regulate also the thickness of the thread. It is well known indeed that the threads in the floss are thicker than those of the cocoon.

As the result of all this, do we know now where the silk comes from? Not at all. In biology, researches only serve to remove questions farther off; new questions always arise.

We must now ask how the cell makes the silk up. Does the nucleus play a part in its production, as seems to be indicated by the changes of form and by the fragmentation it undergoes during the making of the cocoon? The silk, like the nuclein, the essential substance of the nucleus, has a strong affinity for colouring matters. Would this physical property result from a chemical relation between these two complex substances? Is the silk derived from the nuclein? Or, in the other case, from which of the essential elements of the protoplasm does it take its origin?

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4. *On the Placentation of the Dugong.*
By Professor Sir William Turner, *F.R.S.*

In this paper (which will be printed *in extenso* in the 'Transactions of the Royal Society of Edinburgh, 1889') it was pointed out that the placenta of the Dugong is zonary and non-deciduate.

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5. *Observations on the Myology of the Gorilla and Chimpanzee.*
By Johnson Symington, *M.D., F.R.S.E.*

This paper is based upon the dissection of a male gorilla and a female chimpanzee. Numerous anatomists have published descriptions of their dissections

of the muscles of the chimpanzee, but our knowledge of the myology of the gorilla is less complete. So far as can be judged from the limited number of observations it seems probable that muscular variations are about as common in these animals as in man. The differences between the arrangement of the muscles in the gorilla and chimpanzee are undoubtedly less than those between either of these animals and man. It is not easy to determine which of them approaches nearest to man. The following are a few of the more interesting points observed.

In both gorilla and chimpanzee the attachments of the latissimus dorsi and serratus magnus to the trunk were more extensive than in man. This may be associated with their more frequent use in climbing. The dorso-epitrochlearis (Wood) was better developed in the chimpanzee than in the gorilla. In both it was muscular, while in man it is represented by a band of fascia. In both gorilla and chimpanzee the deep head of the pronator radii teres was present, but it is often absent. The radial head of the flexor sublimis was present in gorilla and chimpanzee, and the flexor carpi radialis had also an origin from the radius. The palmaris longus was absent in the gorilla, but present in the chimpanzee. This muscle has only been observed once in the gorilla. The extensor indicis went to index finger only, in the gorilla and chimpanzee. According to Bischoff, the gorilla is the only ape that resembles man in having a special extensor for the index finger. The extensor primi internodii pollicis is said to be peculiar to man. It was absent in the chimpanzee, but present in a rudimentary form in the gorilla, as in the latter a small tendon was prolonged from the extensor ossis metacarpi pollicis to the first phalanx of the thumb. The flexor longus pollicis was represented in the gorilla merely by a small tendon in front of the thumb, which, however, had no connection with the deep muscles on the front of the forearm. In the chimpanzee the index portion of the flexor profundus digitorum gave a small tendon to the thumb. The gluteus maximus is much smaller in the gorilla and chimpanzee than in man, and its arrangement is such as to give rise to a marked difference in the contour of the gluteal region. In the gorilla and chimpanzee the two heads of the biceps flexor cruris were quite distinct, and not joined, as in man. The soleus, however, had a tibial origin. It is generally described in the chimpanzee and gorilla as arising from the fibula only. According to Bischoff, the interossei muscles of the foot are arranged in all the anthropoid apes in the same way as the interossei of the hand, viz., the dorsal interossei abduct from a line passing through the third digit. In the human subject the line is through the middle finger in the hand and the second toe in the foot. I find this to be also the case in the gorilla. In neither gorilla nor chimpanzee was the peroneus tertius present and, so far as I am aware, this muscle has not been observed in the anthropoid apes. It is generally, although not constantly, present in man.

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6. *On the Structure and Function of the Dorsal Papillæ in Nudibranchiata.* *By* Professor W. A. Herdman, *D.Sc.*, *F.L.S.*

The projections from the dorsal surface of the body in Nudibranchs include:—

1. The Rhinophores or dorsal tentacles.
2. The true Branchiæ.
3. The Cerata or dorsal papillæ.

The rhinophores are placed near the anterior end of the body, are supplied by large nerves springing from the cerebral ganglia, and are undoubtedly sense organs. They are present in all the forms I have examined.

The branchiæ, although possibly not ctenidia, are specialised organs of respiration. They are not always present.

The cerata, which are the special subject of this investigation, are often termed dorsal papillæ and branchial papillæ, and have been supposed by some zoologists to function as branchiæ. They are not present in all Nudibranchs, but in many cases they are very large and conspicuous. I find the cerata in the genera which I have examined to be of two kinds:—

1. There are those which contain large diverticula of the liver, as in the case of the genera *Eolis* and *Doto*.

2. There are those which are essentially processes of the body wall, and have no connection with the liver, as in the genera *Tritonia*, *Ancula*, and *Dendronotus*.

The six common British genera, *Doris*, *Ancula*, *Tritonia*, *Dendronotus*, *Doto*, and *Eolis*, show very different conditions of the dorsal processes, and form an instructive series of types. The general anatomy of all these forms is well known,[1] and many points in the detailed histology have been worked out, but the method of serial sections giving the histological relations of the different parts of the body has apparently not been up to now made use of by writers on the structure of the Nudibranchiata.

In *Doris* there are rhinophores at the anterior and well-developed branchiæ at the posterior end of the dorsal surface. There are no cerata or other dorsal processes.

In *Ancula* there are rhinophores, well-developed branchiæ, and large but simple unbranched cerata.

In *Tritonia* there are no branchiæ. The rhinophores are large, and there are small branched cerata along the sides of the dorsal surface.

In *Dendronotus* there is practically the same condition. Branchiæ are absent, but large rhinophores and elaborately branched cerata form the most conspicuous part of the living animal. In the three last-named genera—*Ancula*, *Tritonia*, and *Dendronotus*—the cerata, whether simple or branched, large or small, are merely processes of the body wall and contain no special organs or structures.

In the genus *Doto* there are large rhinophores, no true branchiæ, but a double row along the back of very large complicated cerata, which contain branched cæcal diverticula from the liver. In fact, in this form there is more of the liver in the cerata than in the body proper.

In *Eolis*, finally, we have much the same condition as in *Doto*, except that the processes of the liver in the cerata, although large, are unbranched, and are not cæcal, but communicate with the exterior at their extremities. The cerata also contain at their apices cnidophorous sacs, which open on the one hand to the external world, and on the other into the extremity of the hepatic diverticulum.[2]

The cerata then of *Eolis* and *Doto* are of an entirely distinct nature, and have a very different structure from those of *Ancula*, *Tritonia*, and *Dendronotus*. Of the last group those of *Dendronotus* are by far the most conspicuous and elaborate, and have been generally supposed to contain hepatic cæca like those of *Eolis*. It has been shown, however, by Mr. Clubb and myself, that this is not the case. Serial sections of carefully prepared specimens show that the liver sends up no diverticula into any of the dorsal processes, and that the cerata contain only structures found in other parts of the dorsal and lateral body walls. What have been probably taken in dissections for hepatic processes are large blood sinuses which branch through the cerata and communicate in the body with the large dorso-lateral veins.[3] These ceratal blood sinuses and those of the lateral body walls with which they communicate are at their junction in close proximity to the liver, and might readily, in the absence of serial sections, be supposed to be continuations of that organ, especially as there is usually a considerable deposit of dark-coloured pigment in the connective tissue around the sinuses in the cerata.

The large-branched dorsal papillæ of *Dendronotus* are merely a further development of the small processes of the body wall seen in *Tritonia*.

In regard to the function of these dorsal papillæ in the Nudibranchiata, in the first place I do not think that in any case they are branchial. In *Ancula* and other forms, we find well-developed cerata existing along with true branchiæ, and the two have a distinct structure, so that although in sections the cerata and the branchiæ sometimes overlap and become displaced, one can always distinguish

[1] Our knowledge of these and other Nudibranchiata is very largely due to the admirable investigations of the celebrated Newcastle zoologists, Joshua Alder and Albany Hancock, the authors of the Ray Society Monograph on the British Nudibranchiata and many other papers.

[2] See paper by Herdman and Clubb in *Proc. Biol. Soc. Liverpool*, vol. iii., p. 225, and Pl. XII., 1889.

[3] *Loc. cit.*

small pieces of the one from those of the other. Then in *Tritonia* and *Dendronotus* the cerata agree in structure with those of *Ancula*, and not with the true branchiæ of *Doris* and *Ancula*.

Dendronotus is the form in which it might be most readily believed that the cerata have acquired a branchial function, but a close comparison of sections shows that these processes are not more vascular than the general body wall, and have not even so many lacunæ as some parts of the dorsal and lateral integument. Hence, although they may by their extended surface aid somewhat in respiration, still they cannot be regarded as in any way specialised branchiæ.

Then in *Eolis* and in *Doto*, although from their relatively very large size the cerata may be of importance in respiration, it is merely as being an extension of the general integument, and not as being special respiratory organs. In these two genera also they have been made use of to accommodate the greater part of the liver, and have probably become considerably enlarged.

But I believe that in addition to these minor functions the cerata of the Nudibranchiata are of primary importance in giving to the animal, by their varied shapes and colours, appearances which are in some cases protective and in others conspicuous and attractive, and in this it seems to me we have an explanation of the extraordinary development of these otherwise mysterious processes of the dorsal body wall.

To take a few cases: *Tritonia* (or *Candiella*) *plebeia* is fairly abundant at Puffin Island and at Hilbre Island, near Liverpool, and is always found in those localities creeping over the surface of colonies of *Alcyonium digitatum*. The specimens of *Tritonia* are marked with many colours, including tints of yellow, brown, blue, grey, black, and opaque white; and when examined in a vessel by themselves, considerable differences between individuals are noticed, but when in their natural condition on the *Alcyonium* colony they are nearly all equally inconspicuous. The colonies of *Alcyonium* differ considerably amongst themselves in tint, some being whiter, others greyer, and others yellower than the rest; different parts of the same colony also vary in appearance on account of the different states of expansion of the polypes, and on account of irregularities of the surface, and of adhering sand and mud; so that the varieties of colouring found in the *Tritonia* are suited to the various conditions of the *Alcyonium* colonies. The small-branched cerata along the back of the *Tritonia* aid the protective resemblance not only by contributing to the general colouring but also by their similarity in appearance to the crown of tentacles of the partially expanded polypes. They are placed at just about the right distance apart, and have the necessary tufted appearance.

Then, again, *Doto coronata*, when isolated, is a very conspicuous and brightly-coloured animal, but I find it at Hilbre Island invariably creeping on the under-surfaces of stones on which are large colonies of the zoophyte *Clava multicornis*, and in that position the *Doto* is not readily seen. The gay appearance of this nudibranch is mainly due to the large and brightly-coloured cerata, and these agree so closely in their general effect with the upper ends of the zooids of *Clava*, covered with the numerous tentacles and the clusters of sporosacs, that when the *Doto* remains still it is hidden to a very remarkable extent.

Dendronotus again, with its large branched cerata and its rich purple-brown and yellow markings, is a handsome and most conspicuous object, but I have frequently found it amongst masses of brown and yellow zoophytes and on purplish-red seaweeds, where it was very completely protected from observation, and I did not for several seconds recognise what I was looking at. Now these are all cases where the colouring is protective, and I have no doubt there are many other similar instances to be found amongst the Nudibranchiata, but the species of *Eolis* appear to be in a different category. They are noted for the very brilliant hues of their dorsal papillæ, and they are always conspicuous so far as I have noticed, even under their natural conditions. Then, again, the species of *Eolis* are rarely found hiding in or on other animals, they are not shy and they are active in their habits —altogether they seem rather to court observation than to shun it. When we remember that the species of *Eolis* are protected by the numerous stinging cells in the cnidophorous sacs placed on the tips of all the dorsal papillæ, and that they

do not seem to be eaten by other animals, we have at once an explanation of their fearless habits and of their conspicuous appearance. The brilliant colours are in this case of a warning nature, for the purpose of rendering the animal provided with the stinging cells noticeable and recognisable.

These, then, are the grounds upon which I base my view that the chief function of the cerata is by varied shapes and colours to enable the animals to assume protective or warning appearances as may be found best suited to their surroundings and mode of life.

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7. *On the Electric Light as a means of attracting Marine Animals.* *By* Professor W. A. Herdman, *D.Sc.*, *F.L.S.*

Since the publication in 'Nature' for June 7, 1888, of the chief results obtained by the use of the submarine electric light during one of the Liverpool Marine Biology Committee's dredging expeditions, I have received a number of inquiries from biologists, fishermen, and others as to the details of the apparatus used, and the exact method of illuminating the tow-nets. Consequently, I believe, it may be useful if I lay before this meeting a brief statement of how the electric light has been employed up to the present time in marine biology, and with what results.

The first application of this important method of collecting appears to have been made by the United States Fish Commission in 1884,[1] on board the steamer *Albatross.* On that occasion an arc lamp was merely suspended above the surface of the water, and it was found to attract Amphipods, Squids, and young fish to the surface. In the following year the same naturalists experimented further by lowering an Edison incandescent lamp[2] into the water, with similar good results. The Fish Commission do not give any details in regard to the animals collected, nor any comparison between the contents of illuminated and ordinary tow-nets worked at the same time.

The next submarine electric light experiments were those carried out by the Liverpool Marine Biology Committee in May 1888, on board the steamer *Hyæna* during a three-days' dredging expedition in the Irish Sea. The *Hyæna*, kindly lent by the Liverpool Salvage Association, is provided, for wrecking purposes, with the following electric light installation:[3]—A Gwynne vertical engine, of 6 nominal h.p., running at 300–400 revolutions per minute, works a Phœnix compound wound dynamo, with an effective output of 5,980 Watts (65 volts 92 amperes), at 1,000 revolutions per minute. There are two Pilsen arc lamps of 3,000 nominal c.p. each, which can be used on deck or at masthead or on the side of the ship; four Edison-Swan submarine incandescent lamps of 100 c.p., and ten of 16 c.p. each. The dynamo, being compounded, allows the arc and incandescent lamps to be run together with perfect ease by the use of a resistance of about ·5 of an ohm in the arc-light circuit. The submarine lamps are fitted in strong circular annealed glass protectors, and can be lowered to any required depth in the water by means of a special waterpoof flexible cable, made of 260 strands of fine copper wire, covered with thick guttapercha and hemp. The arc lamps require from 25–30 amperes, and the submarine lamps 4·5 amperes, so that there is ample power when the whole installation is running.

This apparatus was first used for biological purposes in Ramsey Bay on the first night of the cruise. After dark one of the large arc lamps was hoisted a few feet above deck, so as to allow work to be carried on almost as easily as during the day. We then arranged one of the submarine incandescent lamps in the mouth of a tow-net so as to be just well within the iron ring, and yet not too deeply in the net, the object being to illuminate the entrance to the net and not the middle or tail end. This illuminated net was let down to a depth of three fathoms, and at the same time another tow-net without any light was let down to the same depth

[1] *Bull. U. S. Fish Commission*, vol. iv., p. 153.

[2] *Loc. cit.* vol. v., p. 464.

[3] I am indebted to Captain Young, of the Liverpool Salvage Association, for this information in regard to the plant on board the *Hyæna*.

over the other side of the ship. When, after half an hour, the nets were hauled in, as the one with the electric light approached the surface numerous small Crustacea were noticed accompanying it, and darting about in the bright light. This tow-net, when emptied into a glass jar of sea-water, was found to have contained an abundant gathering, consisting mainly of Crustaceans, while the net in the dark on the other side of the ship had practically nothing. The two nets were then put out again, this time to a depth of six fathoms, and at a greater distance from one another, with the same general results as before. These two experiments showed pretty conclusively the effect of the brilliant light in attracting the free-swimming animals, the difference between the contents of the two nets being on both occasions most marked. Consequently, on the second night, in Port Erin Bay, *both* nets were illuminated, and, while the one was let down close to the bottom at a depth of 5 fathoms, the other was kept at the surface. This experiment was tried three times, with the same result each time. Both nets contained abundance of animals, but the bottom and surface gatherings differed greatly in appearance and in constitution—the net from the bottom containing mainly large Amphipoda and Cumacea, while that from the surface was characterised by the abundance of Copepoda. For further details as to the species obtained in these various gatherings I must refer to the article in 'Nature,'[1] and to the reports in the 'Fauna of Liverpool Bay,' vol. 2; on the Copepoda, by Mr. I. C. Thompson; and on the other Crustacea, by Mr. A. O. Walker.

During June of the same summer (1888) Prince Albert of Monaco[2] used on board his yacht *Hirondelle* a tow-net lit by a small incandescent lamp, supplied by a single Bunsen cell (in which the nitric acid is replaced by chromic acid).

The battery, which was let down into the sea along with the net, is hermetically sealed up in an iron case, while, when the apparatus is used in great depths, the pressure is ingeniously equalised by a tube connecting the interior of the case with a strong indiarubber ball filled with air. This apparatus was tried in the neighbourhood of the Azores, down to a depth of about 20 fathoms, but apparently without much success.

In April 1889 the steamer *Hyæna* was again placed at the service of the Liverpool Marine Biology Committee for a five days' cruise,[3] and the opportunity was taken advantage of to make a further series of experiments with nets illuminated by the electric light. On two successive nights in Port Erin Bay, after dark, *both* the large arc lamps were lit up and were suspended half-mast high, so as to throw a strong glare upon the water at the sides of the vessel. Tow-nets provided with submarine lamps were then used both at the bottom (six fathoms) and at the surface, and an ordinary tow-net was dragged by Mr. I. C. Thompson round and round the ship in the brightly-illuminated water. All of these nets gave abundant gatherings, consisting mainly of Copepoda, Amphipoda, Schizopoda, and Cumacea, and differing most markedly from the gatherings taken in the same spot during the daytime without the electric light. In this case there was no difference noticed between the contents of the bottom and of the surface nets, both containing abundance of Cumacea. This difference from the previous year's results was probably due, I think, to our having a much more powerful surface light (6,000 c.p.), which had been shining for at least half an hour before the tow-nets were put over, with the result that the Cumacea and other bottom Crustacea were attracted to the surface from a depth of six fathoms. On the last day of the cruise we took a gathering successfully with an illuminated tow-net from a depth of 30 fathoms, the deepest water on our course from the Isle of Man to Liverpool.

The results of these experiments in Liverpool Bay have been such as to show conclusively that the submarine electric light is an important addition to the collecting methods of the marine biologist, and one which ought certainly to come into extensive use in the future. It is, of course, only very rarely that a vessel like the *Hyæna*, so fitted up that the electric light can be turned on readily at any time

[1] *Nature*, vol. xxxiii., June 7, 1888.
[2] *Comptes-rendus*, t. cvii., July 9, 1888.
[3] For the general results of this cruise see *Nature*, May 9, 1889.

to illuminate a series of nets, is placed at the disposal of the biologist, and to fit out a boat specially with an engine and dynamo and a set of lamps would be a very expensive matter. I thought at one time that storage batteries might serve the biologist's purpose, but on making inquiries in Liverpool we found that for even a day's work a considerable number of batteries would have to be taken, and the expense would be too great. The plan of sending a primary battery down in the net, as in the case of the Hereditary Prince of Monaco's experiments, seems on the whole—if it gives a bright enough light and works satisfactorily—to be the simplest and most economical method, and the one which it would be best to adopt where no vessel already provided with an electric installation is available.

As to the practical application of this method to fisheries, although there can be no doubt that the electric light acts powerfully in attracting many free-swimming animals, and especially Crustacea, I think there is no good evidence that it attracts marine fishes; and, although more experiments are required before the matter can be considered as settled, I am inclined at present to agree with the opinion which has been expressed by some of the American investigators, that the method is of more value to the scientific biologist than to the practical fisherman.

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8. *On the Caudal Respiration of* Periophthalmus. *By* Professor A. C. Haddon, *B.A., F.Z.S.*

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9. *The Stomach of the Narwhal: the bearing of its Histology on Turner's and Max Weber's Nomenclature of the Stomach of the Ziphioid and Delphinoid Whales. By* G. Sims Woodhead, *M.D., and* R. W. Gray.

In a communication we gave before the Royal Society of Edinburgh last winter we described, somewhat minutely, the histological structure of the stomach of the narwhal (*Monodon monoceros*). When this was written we had not read either Professor Sir W. Turner's [1] or Professor Max Weber's papers,[2] in both of which we have most valuable observations and generalisations on the stomach of the cetaceans.

It is evident, on reference to the three papers, that although the main facts and observations in all three are interpreted in much the same manner, there are slight differences of opinion on some of the minor points.

It is agreed that in all cetaceans, with the exception of the ziphioids, the stomach is divided into what may be called an œsophageal portion and a true stomach, but there is some difference of opinion as to the methods of division and nomenclature to be adopted in describing this true stomach.

The first compartment or œsophageal diverticulum retains all the histological elements and structure of the upper part of the œsophagus. The mucous membrane is thick, the horny cells are arranged in regular lamellæ, the deeper cells are polygonal. The folds described by Turner we find to be true papillæ, which appear to project upwards as delicate filiform processes, ramifying somewhat irregularly. This irregular ramification is sometimes so marked that masses of epithelium seem to be cut off, these then appearing to be very like gland acini, for which, in allied species, they have by some observers, been mistaken.

We assigned to this cavity a function which has been most aptly termed 'maceration' by Turner in the paper above referred to. He speaks of this first portion of the digestive apparatus as a 'macerating chamber.'

In regard to the second compartment, or first true digestive cavity, there is general agreement. It is spoken of as the cardiac or proximal division in all three papers. For convenience of reference this is perhaps the best term. The glands in the thick mucous membrane of this cavity are closely packed together and are very numerous. They are simple, unbranched tubes, each continued downwards

[1] 'Additional Observations on the Stomach in the Ziphioid and Delphinoid Whales,' *Journ. Anat. and Phys.* vol. xxiii., pp. 466 *et seq.*

[2] *Morph. Jahrb.* 1887–8, pp. 637 *et seq.*

from a duct of its own, running straight from the surface to the submucosa, where it ends in a short hooked extremity. The secreting portion of the walls of these glands is formed by a double layer of cells; a central or columnar layer, near the mouth of the duct, the cells of which, however, are more cubical in the deeper portion of the gland. Outside this is a second or parietal layer completely investing the tubule (and not occurring at intervals as in the cardiac glands of the stomach of the dog and human subject, and as described and figured by Max Weber). These cells are large nucleated granular protoplasts, irregular in shape, slightly flattened, pyramidal, and each lodged in a distinct cavity formed by a framework of delicate connective tissue on which small flattened nuclei are seen. This reticulum corresponds apparently to that in the same position in the pig and in the porpoise (described by Heidenhein). It appeared at first sight as though the large parietal cells were entirely surrounded by the delicate strands, but on more careful examination we came to the conclusion that there is a small orifice in the inner wall of the space through which the two sets of cells are brought into direct communication. The part of the stomach after this is somewhat differently described and named by different authors. Max Weber considers that the whole of the stomach after the cardiac portion should be considered as corresponding to the pyloric portion of the stomach of the carnivora. He says the glands are mucus-secreting, and that in other respects they are like those found in the carnivora. He goes on to say that the cetacean stomach can be compared, in some respects at least, with the form of stomach met with in the Pinnipedia, in which the pyloric portion is sharply defined from the cardiac. Turner, on the other hand, basing his description and nomenclature on observations on a large number of species of both ziphioid and delphinoid whales, divides this portion of the stomach into intermediate and distal or pyloric divisions. Although neither of these methods of division and naming is absolutely accurate, so far as our observations go, we are inclined to look upon Turner's as the more convenient. In the first place, on examination of the next division, which we should have to call first pyloric or first intermediate division, it is found that at its 'cardiac' end there are in the deeper portions of the secreting glands a number of the large parietal cells, similar to those found in the cardiac glands, whilst at the distal portion of the cavity there are found only ordinary columnar epithelial cells, resting on a basement membrane of flattened nucleated cells. These columnar cells correspond to the pyloric or central cells. In this case, then, the cavity is certainly intermediate in character in whatever light it may be viewed. The two following divisions resemble one another very much in all respects. The glands are all lined by cubical epithelial cells, and in the deeper parts the secreting tubules branch and are somewhat irregular in their mode of termination. These two divisions then must be looked upon as the true pyloric part of the stomach unless some characteristic and distinctive features can in future be found.

It would appear probable from a careful study of Turner's descriptions that in the narwhal the intermediate portion is not so fully developed as in the ziphioid, but that the pyloric portion is somewhat more complicated, and approaches more nearly the description given by Max Weber.

In this instance, however, there is not that sharp line of demarcation at the junction of the cardiac and intermediate cavities between the cardiac and pyloric glands. We find the former extending for some distance into the intermediate compartment, so that Max Weber's comparison of the stomach with that of the Pinnipedia does not altogether hold good. We have a condition similar to that found in the stomach of the rat, in which the squamous œsophageal epithelium extends for some little distance into the cardiac cavity, *i.e.*, beyond the cardiac orifice.

In the delphinoid cetaceans, then, there is always an œsophageal paunch, to which Turner has given the most appropriate name of macerating chamber. This is in no sense of the term gastric, but it helps as a storage and macerating cavity from which may be regurgitated refuse material. In both ziphioids and delphinoids there is a true distal or cardiac cavity lined with a layer of 'cardiac' glands. Then follow what Turner calls the intermediate divisions, from his description, numerous

in Sowerby's whale, fewer in Hyperoodon rostrates, and, according to our observation, present as a single small cavity only in the narwhal.

The division is followed by the single pyloric cavity, according to Turner, but in the narwhal by two divisions, both of which are lined by 'pyloric' mucous membrane. Until we have a most careful examination of the mucous membrane from different parts of all the cavities in the various species, it will evidently be unsafe to generalise too widely, as from what we have observed we cannot bring the stomach of the narwhal entirely under the classification given by either Turner or Max Weber.

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10. *On the Secretion of Carbonate of Lime by Animals.* *By* Robert Irvine, *F.C.S., and* G. Sims Woodhead, *M.D.*

Hens supplied with any salt of lime produce normal egg-shells composed of *carbonate of lime.* They cannot make shells from magnesium or strontium carbonate. Crustacea, such as crabs, cannot assimilate sulphate of lime from the sea-water to form their exo-skeleton. They can form their shells from calcium chloride.

In the egg-shell, the organic and inorganic material are both secreted by cells separated from the epithelial cells. In the crab-shell the organic material (chitin) remains attached to the epithelial cells, and in this the lime salts are deposited, probably by a process of dialysis, whilst in the case of bone, the cells are not epithelial in character, the matrix though separate is closely associated with the cells, especially during its formation, and the lime is deposited in the matrix apparently by a process of dialysis. Phosphoric acid, combined with alkalies and alkaline earths acts as the carrier of the lime salt to the secreting cells. While in the blood the lime salt is as a phosphate; it may be thrown out mostly as carbonate on meeting nascent carbonic acid at the secreting cells.

Lime salts, of whatever form, are deposited only in vitally inactive tissue such as bone matrix, chitin, or tissues that have undergone degeneration. Although the tissue be dead deposition may go on.

Carbonate of lime may be formed in sea-water as follows: the carbonate of ammonia produced by the decomposition of the effete products of animals, urea, etc., decomposes a portion of the sulphate of lime in the sea-water with the formation of carbonate of lime equivalent in amount to the carbonate of ammonia thus formed.

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11. *On the Solubility of Carbonate of Lime in Fresh and Sea Water.* *By* W. S. Anderson.

Mr. Anderson stated that during last winter he had, at the request of Dr. Murray of the 'Challenger' expedition, continued the investigation of Messrs. Irvine and Young on the solubility of carbonate of lime in its different forms in sea-water. Special attention had been given to the solubility of amorphous and artificially crystallised carbonate of lime, and the various forms of coral in sea-water. The results showed that crystallised carbonate of lime was somewhat more soluble in pure water than in sea-water, and that amorphous carbonate of lime was more soluble in sea-water than in pure water. When sea-water stood over crystallised carbonate of lime for a lengthened period it first dissolved and then reprecipitated it again. This was supposed to be an agent in the petrifaction of the porous masses of coral reef. The soluble action of sea-water on carbonate of lime was independent of any carbonic acid present, for an artificial sea-water free from carbonic acid would dissolve as much whether crystallised or amorphous. The action was limited to the saline constituents of the sea-water. The action was simply that of solution, not of chemical change into sodium carbonate and calcium chloride. The soluble action of each constituent, water and salts, when taken together showed that the surplus base already present in sea-water need only be the single carbonate of lime and not the bi-carbonate.

TUESDAY, SEPTEMBER 17.

The following Papers were read:—

ZOOLOGICAL DEPARTMENT.

1. *On the Restoration of* Asterolepis maximus (*Agassiz*), *with remarks on the Zoological Affinities of the Pterichthyidæ. By* Dr. R. H. TRAQUAIR, *F.R.S.*

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2. *On some new and rare Copepoda recently found in Liverpool Bay. By* ISAAC C. THOMPSON, *F.L.S., F.R.M.S.*

The paper may be taken as supplementary to one read by the author at the Manchester meeting of the Association in 1887, in which several species of Copepoda new to Britain were referred to. The investigation of this class of microscopical Crustacea has been actively continued in connection with the scheme of the Liverpool Marine Biology Committee (L. M. B. C.), instituted by Professor Herdman five years ago for investigating the fauna of Liverpool Bay, and of whose researches a second volume has recently been published.

Ninety-four marine species of Copepoda have already been found in the district, the present paper referring especially to eleven of these which are new to Britain, four being new to science.

The latter are *Cymbasoma Herdmani, Hersiliodes puffini, Jonesiella hyenæ,* and *Lichomolgus sabellæ*, and have been or will be fully described in the 'Proceedings of the Liverpool Biological Society.' The others new to Britain not referred to in the previous paper are *Paracalanus parvus*, Claus, *Pontella Kroyeri*, Brady, *Giardella callianassæ*, Canu, *Lichomolgus albens,* Thorell, *Cymbasoma rigidum*, Thompson, *Lernæa branchialis*, Linn, and *Artotrogus orbicularis*, Boeck.

The establishment of the biological station on Puffin Island at the entrance to the Menai Straits has proved of immense benefit in the investigation of marine fauna, most of the above species, as well as many other rare ones new to the district having been there taken by tow-net, or in the numerous tidal rock-pools, mud deposits, or parasitic on other animals.

By the use of the electric light while cruising in the steamer 'Hyæna,' belonging to the Liverpool Salvage Association, many valuable species of Copepoda and other free-swimming Crustacea have been taken. The modus operandi has been described by Professor Herdman (' Nature,' May 9, 1889), and includes the brilliant illumination of the surface of the sea, that portion being meanwhile skimmed by tow-nets, and also the illumination at the sea-bottom and intermediate depths by means of submarine incandescent lamps of fifty-candle power fitted into the mouths of finely-meshed tow-nets. The Copepoda thus taken by the deep tow-nets included numbers of the genus *Harpacticus* of remarkably large size, and the theory seems tenable that they, being well known as foul feeders, mistook the electric light for the phosphorescent glow of decomposing animal matter.

The results obtained from the brilliant surface illumination were very striking. The examination of the Copepoda obtained by slowly dragging a surface tow-net over the illuminated portions of the sea round the vessel, yielded twenty separate species in one haul. They include some very rare ones, notably *Pseudocalanus armatus*, Boeck, which has not before been recorded in Great Britain except at great depths in the Clyde. Amongst the other uncommon forms were *Ectinosoma atlanticum, Zaus spinatus, Laophonte lamellifera, Dactylopus tenuiremis, D. tisboides, Cyclopina gracilis, Bradya typica,* and *Euterpe gracilis*. With them was a perfect shoal of *Peltidium depressum*, a species usually confined to the fronds of Laminaria, and attached to other Algæ. It is evident that the electric light is able to draw these minute Crustacea from their secret hiding-places in a remarkable manner, and considerable further results are anticipated from this source. The paper deals with the geographical distribution of Copepoda and their gregarious habits, and their prevalence as affected by commerce and the drainage of large cities.

3. *On Photography as an aid in Anatomical, Histological, and Embryological Work.* *By* Professor Fraser, *M.B.*

All morphologists will agree that the labour involved in illustrating their work properly is very great, and that any aid that would lessen this would be gladly welcomed by all, especially when that aid can illustrate in a manner with which they cannot hope to compete, however skilful their pencils may be.

In my own experience I soon found that the Camera Lucida was totally inadequate to illustrate in a reasonable time all the work which lay on my hands; while in adult anatomical work one's own hand, or even that of the skilled artist, could never reproduce with the same finish and accuracy what I am now able to accomplish with but little trouble.

In adopting the photographic method, then, I had two ends in view: the first was to reproduce the entire structure of the several divisions of the body, life-size; while the object of the second was to produce enlargements of my serial histological and embryological sections for purposes of reconstruction.

For the attainment of the first end I had to employ a very large apparatus, arranged to work vertically, with a rapid rectilinear lens of long focus, so as to give me proper working distance to reproduce natural size, while by the correct use of diaphragms (down even to pinhole ones) I was able to travel, dissection after dissection, through the particular division of the body at which I was working, without ever shifting the apparatus or the preparation; while by numerous combinations, all taken direct from nature, as I went along I practically made that particular division transparent.

For the attainment of the second end I had to use an enlarging apparatus with a rapid rectilinear lens of short focus and the oxyhydrogen light. In addition I had special carriers made, holding twelve slides of the Leipsic or eighteen of the English form at one time, so that I could make twelve or eighteen exposures without further trouble than simply pushing the carrier along the breadth of a slide and changing the sensitive paper, each exposure; using the Eastman Bromide paper and full aperture of the lens lasting only four seconds.

In this manner, then, I could run through the serial sections of a small adult rodent's brain, or serial sections of embryos, in a few minutes, enlarging up at one operation all the sections under a cover-glass measuring 40 by 30 mm., these being often one hundred in number.

The ease and celerity with which this can be done, and the beauty of the enlargements, have to be seen to be appreciated; whilst the every-day aid that the method can yield, both in teaching and original work, will soon lead to its more general adoption.

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4. *Our Local Industries in their Social and Pathological Aspects.* *By* Thomas Oliver, *M.A., M.D., M.R.C.P.*

Dr. Oliver, in introducing the subject, drew attention to the frequent occurrence of diseases of the cardio-vascular and nervous systems in the district—a frequency explained, to a great extent, by the habits and occupations of the people. The question of lead-poisoning was then discussed, as also the social life of the industrial classes.

In the three northern counties of Northumberland, Durham, and Cumberland, it is estimated that 116,590 people are employed about coal mines. To the heated atmosphere of the coal mine—an atmosphere often laden with dust—and to the strain thrown upon the internal organs caused by the cramped position in which miners are obliged to work, were attributed some of the diseases from which coal miners suffer. Half a century ago a form of phthisis, known as anthracosis, in which the lung became saturated with carbon pigment, was more or less the scourge of some of the mining districts. Thanks to the improved ventilation of mines, this lung affection is seldom met with now. Beyond the frequency with which miners suffer from the effects of injuries received at work, and the fact that scrofulous disease of bone and joints is of common occurrence amongst coal miners, Dr. Oliver

did not regard miners as a class strongly predisposed to any particular kind of ailment in marked excess of others of the industrial classes.

Ironstone and lead miners do not suffer in any special way; but the workers in iron—particularly the puddler and striker—are apt to suffer from disease of the heart and aorta owing to the strain thrown upon their blood-vessels.

Although lead miners escape, lead smelters and all who are engaged in the manufacture of lead—particularly white lead—run a very great risk of being contaminated sooner or later. Tyneside is the chief centre of the lead trade, and unfortunately it supplies the opportunity for the study of plumbism in all its phases. Dr. Oliver showed that whilst the more chronic effects of lead-poisoning were found chiefly in the kidneys and nervous system, the acutely fatal form of plumbism attacks young girls, from the ages of 18–23, who have only worked in the white lead for a few weeks or months. In them a toxæmia is quickly developed: headache, blindness, colic, disordered menstruation, are the symptoms complained of; and unless those thus suffering are at once removed from the leadworks and carefully treated—nay, even then—death may follow—epileptic convulsions and coma, as a rule, preceding the fatal event. In many of the internal organs, *post mortem*, lead has been found, but in very small quantities—not more than a grain or two in the brain, for instance. As death under these circumstances has been rapidly induced, no marked structural change is detected in the internal organs. The pathology of chronic lead-poisoning is structural alteration of heart and kidneys, and central and peripheral changes in the nervous system.

Beyond suffering from bronchial affections, chemical labourers and millers have no special disease that can be regarded as their own; nor do cement-makers, workers in copper, cattle-drivers, suffer from any special illness. Shop-girls and milliners suffer largely from anæmia, and the former from the mechanical effects of being too much on their feet.

The question of the price of food, house accommodation for the working classes, and overcrowding was next dealt with. Recent town improvements had necessitated the demolition of many houses occupied by the labouring classes, and these had not been rebuilt. As a consequence, a large body of the people had removed to the outskirts of the town.

The vice which seems to be on the increase amongst the working classes of the district is betting. This was thought to be confined to some trades more than others.

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5. *Note on the Importation and Colonisation of Parasites and other Natural Enemies of Insects injurious to Vegetation.* *By* C. V. RILEY, *Ph.D.*

The encouragement of the natural checks to the increase of insects injurious to vegetation may be of a twofold nature. It frequently happens that an indigenous species is found to have certain parasites in only a portion of the country which it inhabits. In such cases, where it is practicable to transport the parasites, a great deal of good may be accomplished. Cases in point are not uncommon. Some of the Chalcid and Mymarid parasites of certain scale-insects (family *Coccidæ*) are thus easily sent from one place to another (cf. my third, fourth, and fifth reports on 'The Insects of Missouri,' 1870–72). Again, in the case of the Plum-curculio (*Conotrachelus nenuphar*), a widespread indigenous snout-beetle which seriously affects the plum and a great deal of other stone fruit in the United States, this beetle is known to have certain Braconid parasites, which undergo their transformation below ground, the larva forming a tough cocoon, in which it or the pupa is easily transported by post or otherwise. (*Vide* third report, 'Ins. Mo.' 1870.) Other similar cases will occur to the experienced.

But this intentional distribution of the parasites or natural enemies of an injurious insect from one part to another of its native country is by no means to be compared in importance with the introduction of such parasites or enemies from one country to another, in which the injurious species has obtained a foothold, without the corresponding natural enemies which serve to keep it in check in its original home.

The object of the present note is to cite an illustration of artificial introduction on a large scale, which has already been productive of great good. A successful attempt of this kind has been made by me in the case of *Microgaster glomeratus*, which, after several futile efforts, was introduced from Europe and established in the United States in 1885, and which has now become so widely distributed as to raise the question of its previous existence there. This Microgaster is one of the commonest parasites of the European Cabbage Worm (*Pieris rapæ*), which got a foothold in America, without its European enemies, about the year 1859, and which rapidly spread over the States and parts of Canada with disastrous results to the cabbage crop.

The case to which I would particularly allude is, however, far more important and satisfactory. Orange culture has become a very important industry in Southern California. The orange groves there have suffered for some years from the attacks of several insects, but particularly of a very pernicious scale-insect, *Icerya purchasi*, Maskell. This is one of our largest Coccids, and from its habits and characteristics very difficult to overcome. It does a great deal of damage, not only to the orange and other citrous fruit-trees, but to many other cultivated plants. The damage has become so serious during the past few years that many orange growers have abandoned their groves, while the cost and trouble of protecting these by the use of insecticides have always been great even where successful. After careful researches, I ascertained that the insect was, without much question, a native of Australia, and had been artificially introduced not only into Southern California but also into Cape Colony in South Africa, and probably into New Zealand; also that in its native home it rarely did serious damage, being kept in check there by various natural enemies and parasites. Some attempt was made, through correspondence with Mr. Frazer Crawford, of Adelaide, to introduce one of the parasites by mail in 1887. Specimens were received alive, and liberated at Los Angeles under confinement; but no positive evidence was obtained of multiplication or colonisation. Special effort and introduction on a larger scale seemed necessary. Last autumn and winter, in connection with the Commission appointed to visit the Melbourne International Exposition, and through the State Department, I was able to send one of my field agents, Mr. Albert Kœbele, to Australia, with instructions to study these natural enemies and to send living specimens to California. The principal facts have been recorded in my last annual report as Entomologist of the United States Department of Agriculture, and in late numbers of 'Insect Life,' a monthly bulletin published under the auspices of the Entomologist and his assistants. Without going into detail, I may say that Mr. Kœbele's mission has been eminently successful, and that we have succeeded in introducing alive not only the most important of the parasites, an interesting Dipteron (*Lestophonus iceryæ*, Williston), but also several predaceous species, and particularly certain ladybirds (Coccinellidæ). These were brought over last winter and spring, have become well acclimatised, and are now spreading and multiplying at a rapid rate. The latest reports which I have received from California are to the effect that one of the commoner ladybirds, but recently described, namely, the *Vedolia cardinalis*, and another (lately described by Dr. D. Sharp as *Scymnus fagus*), are multiplying and spreading in a most satisfactory manner. The consignments from Australia were received at Los Angeles by Dr. D. W. Coquillet, another of the agents of the Division.

The first consignment of the Vedolia was received November 30, 1888, and numbered 28 living specimens of larvæ, pupæ, and beetles; the second consignment was received December 29, and contained 45 specimens in their different stages; and the third consignment of 56 specimens was received January 24 of this year, making in all 129 specimens, which were placed under tent. From the very first these Coccinellidæ throve and played havoc with the Iceryas. By the latter part of April they had increased to such an extent that it was deemed advisable to send out colonies to different parts of the State, and up to date of my last advices, the beginning of June, over 4,000 specimens had been sent to various parties who had applied for them, while there were fully 2,000 specimens still remaining where colonised. 'These 6,000 individuals,' writes Mr. Coquillet,

'are the progeny of the original 129 insects referred to above, which will give some idea of the rapidity with which these insects breed. Several of the orange-trees at Mr. Wolfskills have been almost entirely cleared of the Iceryas by these ladybirds, and on the other trees their numbers are becoming rapidly lessened through the persistent attacks of their merciless foes.'

Besides the 129 specimens referred to above, two later consignments were received. One of these arrived February 21, and consisted of 35 specimens, which were colonised on an orange-tree in the San Gabriel Valley. A much larger consignment, containing about 350 specimens in different stages, was received March 20, some of which were also colonised at the same place, while the remainder were placed in another grove.

The increase of the *Lestophonus* is more slow. Speaking of these importations in my last report (p. 90), I remarked: 'We fully expect to learn of the increase and rapid spread of this new introduction as well as of some of the other predaceous species which have been introduced, and to find that in a comparatively few years the orange groves of Southern California will be kept measurably free of the pernicious fluted scale without so great an effort on the part of the growers or so great expense in destroying it. That nature will, with the new conditions induced by these importations, come to the relief of the fruit-grower, and that this interesting experiment will result in the ultimate saving of untold millions to the people of the Pacific coast, is our sincere belief, which we hope to live to see verified. Not that we expect the Icerya to be ever entirely exterminated, but it will be kept under subjection so as to be comparatively harmless, as it is in its native country.'

These predictions are in a fair way of realisation, and the instance is of sufficient scientific and economic interest to justify the sending to the British Association of this abstract of a fuller note which I have sent to the American Association on the subject.

6. *The Uses of the Testaceæ or Conchiferous Molluscs in Nature, Science, and the Arts. By* B. W. GIBSONE.

7. *On the work done at the Laboratory of the Marine Biological Association in the past year. By* G. C. BOURNE, *M.A.*

8. *The Morphology of the Antipatharia. By* G. BROOK, *F.L.S.*

9. *Some Remarks on the Functional Equivalency of certain Parts of Limbs. By* Professor R. J. ANDERSON, *M.A., M.D.*

Professor Owen has discussed the serial homology of parts of limbs. His opinions are generally accepted. The analogy of certain structures is fully explained by the same anatomist, who takes care to show that things that are analogous are not necessarily homologous. The close relationship of function and structure is well seen in joints, and a classification according to function in human anatomy corresponds very nearly to a classification according to structure. I think an attempt may be made to determine the *functional equivalency* of parts of the fore and hind limbs in mammals.

1. By 'functional equivalency' I mean the equivalence of the actions of certain parts of limbs in their bearing on the animal as a whole. The front limb of the horse is elevated by a backward bend at the elbow, whilst the posterior is elevated by a bend back at the heel. The elbow and ankle may then be regarded as 'functional equivalents.' The functional equivalency is less apparent in some animals than in others. Many anatomists have made measurements of the limbs and their segments in many animals. I have done the same, and submit a list of measurements in different breeds of dogs I have also compared.

The following table gives the measurements in millimetres in a series of dogs:—

—	Scapula	Humerus	Forearm and Hand	Foot
Sheep Dog	200	212·5	375	192
" "	152	178	305	165
Scotch Collie	176	188	292	174
Water Dog	—	185	300	188
" "	168	186	317	193
" "	190	152	305	165
Retriever	190	187	340	196
Cocker Spaniel . . .	166	153	257	153
Irish Setter	190	235	394	216
" "	—	—	356	200
Pointer	216	228	365	203
Greyhound	216	229	400	210
"	216	254	404	216
Irish Terrier	190	235	394	216
" "	147	131	200	128
" "	147	172	253	150
English Terrier . . .	149	140	222	132
Toy Terrier	—	—	130	88
English Fox-terrier . . .	138	135	232	135
Spanish Terrier . . .	152	159	252	139
Bull Terrier	163	138	241	140
Bull Dog	165	152	254	152
" "	165	152	248	156
St. Bernard	238	225	420	230
Otter Hound	170	169	238	147
" "	137	210	225	192

The following table gives the ratio of the measured lengths of the forearm and *Manus* to the *Pes* in dogs:—

Sheep Dog	$\frac{375}{192} = 1·9531$	Pointer	$\frac{365}{203} = 1·798$
" "	$\frac{305}{165} = 1·8484$	Greyhound	$\frac{400}{210} = 1·904$
Scotch Collie	$\frac{292}{174} = 1·6781$	"	$\frac{404}{216} = 1·870$
Water Dog	$\frac{300}{188} = 1·597$	Irish Terrier	$\frac{394}{216} = 1·824$
" "	$\frac{317}{193} = 1·6424$	" "	$\frac{200}{128} = 1·562$
" "	$\frac{305}{165} = 1·848$	" "	$\frac{253}{150} = 1·686$
Retriever	$\frac{340}{196} = 1·734$	English Terrier . .	$\frac{222}{132} = 1·681$
Cocker Spaniel . . .	$\frac{257}{153} = 1·679$	Toy Terrier . . .	$\frac{130}{88} = 1·477$
Irish Setter	$\frac{394}{216} = 1·731$	English Fox-terrier . .	$\frac{232}{135} = 1·718$
"	$\frac{356}{200} = 1·78$	Spanish Terrier . .	$\frac{252}{139} = 1·812$

Bull Terrier . . .	$\frac{241}{140} = 1{\cdot}721$	St. Bernard . . .	$\frac{420}{230} = 1{\cdot}826$
Bull Dog	$\frac{254}{152} = 1{\cdot}671$	Otter Hound . . .	$\frac{238}{147} = 1{\cdot}619$
" "	$\frac{248}{156} = 1{\cdot}588$	" "	$\frac{225}{192} = 1{\cdot}171$

2. The structure to be found in the functionally equivalent parts and their neighbouring parts. This comparison is exceedingly instructive.

I submit that such functional equivalence may be easily mistaken for homology, even at a very early period.

The following table shows how very closely the parts above and below the ankle-joint may come to resemble the parts in the neighbourhood of the elbow:—

Anterior Limb.		Posterior.
Serratus magnus . . Levator anguli scapulæ. Omohyoid . . . Subclavius . . .	Cervical and upper brachial.	Adductors—Obturator. External rotators—sacral.
The Deltoid . . .	Brachial.	Tensor vaginæ femoris and glutei . . . . } Superior gluteal.
Mastohumeral . . Levator anguli sc. .	Cervical.	Sartorius Ilio-psoas } Anterior crural.
Supraspinatus . . Infraspinatus . .	Brachial (upper.)	Vasti—antr. crural.
Superficial flexors—median . .		Superficial flexors—Int. plantar.
Deep flexors—ulnar and median .		Accessorius ulnar ext. plantar.
Extensors. Posterior interosseous .		Extensors. Anterior tibial.
Flexors. Median and ulnar . .		Peronei. Musculo-cutaneous.
Extensor communis digitorum . . Extensor minimi digiti . . .		Extensor longus digitorum.
Supinator longus . . . . Extensores carpi radialis . . .		Tibialis anticus.
Extensor carpi ulnaris . . .		Peroneus tertius.
Extensor primi internodii pollicis .		Extensor brevis digitorum.
Extensor secundi internodii . . Extensor indicis		Extensor proprius pollicis.
Anconeus		—
Supinator brevis		Posterior intertransverse in frog.
Pronator teres		Peroneus quartus.
Flexor carpi radialis		Peroneus longus.
Palmaris longus.		—
Flexor sublimis digitorum . .		Extensor brevis digitorum.
Flexor carpi ulnaris		Peroneus brevis.
Flexor profundus digitorum . .		Accessorius and flexor longus.
Flexor longus pollicis . . .		Accessorius and flexor longus.
Pronator quadratus		—
Triceps		Gastrocnemius and Soleus.
Gleno-ulnaris		Popliteus.
Subscapularis . . . . . . Latissimus dorsi . . . . . Teres major		Gluteus maximus and Biceps.
Deltoid		Tensor vaginæ femoris and Glutei minores.
Trachelo-humeral		Sartorius.
Pectoralis major		Semimembranosus and gracilis semitendinosus, posterior part of Abductor magnus.
Subclavius.		Pectineus (part).
Omohyoid		Pectineus.

Anterior Limb.	Posterior.
Levator anguli scapulæ	Iliopsoas.
Serratus magnus	Abductors and external rotators attached to the tuberosity.
Supra-spinatus	Internal vastus.
Infra-spinatus	External vastus.
Arteries.	
Ulnar	External plantar.
Radial (superficial volar)	Internal plantar.
Continuation of radial	Anterior tibial (peroneus).
Brachial	Posterior tibial.
Axillary	Sciatic (femoral at back of thigh).
Nerves.	
Brachial plexus	Sciatic.
Cervical plexus	Lumbar.
Cutaneous Supply.	
Cervical supplies skin over shoulder	Lumbar plexus supplies skin over thigh and inner part of tibia.
Brachial—Arm, forearm, hand	Sacral—leg and foot.
Spinal—The skin over latissimus	The skin over Gluteus.

Muscles.

Gluteus maximus, Biceps	Sacral.	Latissimus, Subscapularis, Teres major	Brachial.

Botanical Department.

1. *On the State of the Water in Living Protoplasm.* *By* Professor M. M. Hartog, *Ph.D.*

2. *On Epinasty and Hyponasty.*[1] *By* Professor S. H. Vines, *F.R.S.*

The object of the observations described in this paper is twofold: first, to ascertain whether the epinasty and hyponasty exhibited by dorsiventral members are spontaneous or induced, with special reference to Detmer's conclusion ('Bot. Zeitung.' 1882) that epinasty is induced by light; and, secondly, to ascertain whether the change from the horizontal to the erect position, which is exhibited by many dorsiventral members on being kept for some time in darkness, is due to inherent causes, or to the action of gravity inducing negatively geotropic curvature, as urged by Frank ('Die natürliche wagerechte Richtung von Pflanzentheilen,' 1870) and others.

With regard to the first point, Detmer's conclusion is based upon the observation that the cotyledons of *Cucurbita*, when the seedling is kept in darkness, do not separate, but remain erect, with their upper surfaces in contact, and that, under similar circumstances, the primordial leaves of *Phaseolus* do not become fully expanded. The author points out that the cotyledons of *Cucurbita* are, as a matter of fact, found to separate in darkness if the observations are continued for a sufficiently long time, but agrees with Detmer that the leaves of *Phaseolus* do not become fully expanded under these conditions. The explanation of these facts suggested by the author, in opposition to Detmer, is that light does not induce epinasty, but that it simply induces the phototonic condition which promotes the

[1] Published in full in *Annals of Botany*, vol. iii., 1889.

growth of the leaves, and that since the leaves are inherently epinastic, their renewed growth under the influence of light is necessarily epinastic also.

The author then adduces a number of observations made on various plants, such as species of *Helianthus*, *Fuchsia*, *Dahlia*, *Impatiens*, which prove that epinasty is spontaneous, since the leaves of these plants showed well-marked epinastic curvature when kept in darkness for twenty-four hours or more.

With regard to the second point, the assumption that dorsiventral members are negatively geotropic is based chiefly on the behaviour of young radical leaves of various plants such as *Plantago*, *Taraxacum*, &c., and of the thallus of *Marchantia*, when kept in darkness in the normal position. The author cites experiments in which the plants were rotated on the clinostat in darkness—the influence of gravitation being therefore eliminated—the result of which was that the leaves performed exactly the same movements under these conditions as when the plants were standing in the normal position. From this it follows that the movement in question cannot be due to the action of gravitation, but must be ascribed to inherent causes determining the more rapid growth of the under side of the leaf,—that is, to hyponasty. The same result was obtained in experiments with *Marchantia*.

The author then goes on to analyse the causes which determine the position ultimately assumed by dorsiventral members when growing under normal conditions. These causes he believes to be three: the inherent mode of growth of the member; the action of light; the action of gravitation.

The author considers that the action of light is such as to induce the member to place its upper surface at right angles to the incident rays; he agrees, therefore, with Frank, C. Darwin ('Movements of Plants,' 1880), and F. Darwin ('Journ. Linn. Soc.,' xviii., 1881) that dorsiventral members are diaheliotropic. The fact on which he bases this conclusion is this, that leaves which have become curved, either epinastically or hyponastically, in consequence of having been kept in darkness, return to the horizontal position when fully exposed to light. In these cases light produces two opposite effects: it causes epinastically curved leaves to rise into the horizontal plane, and hyponastically curved leaves to sink down into the horizontal plane. It seems impossible to explain these facts otherwise than on the assumption that epinastic and hyponastic members possess the same kind of irritability with reference to the directive action of light—an irritability which causes them both to assume the same position under its influence.

With regard to the action of gravitation, the author, having proved that hyponastic dorsiventral members are not negatively geotropic, suggests that this is probably true of all kinds of dorsiventral members, since there is absolutely no evidence to prove the negative geotropism of epinastic members. This being so, the question arises whether or not dorsiventral members are at all sensitive to the action of gravitation, and, if so, what the nature of their reaction may be. The author does not profess to have fully investigated this subject, but he describes some observations made on plants placed in darkness, with their long axes horizontal, which tend to prove that the action of gravitation upon the leaves is to bring them into such a position that their upper surfaces are horizontal and face the zenith. He therefore supports Frank's theory of diageotropism. In these observations the effect of epinasty and hyponasty had to be taken into account in ascertaining as far as possible the nature and the extent of the effect due to gravitation.

These conclusions will be rendered more intelligible when they are applied to the elucidation of particular cases. For instance, the leaves of *Helianthus*, as mentioned above, are strongly epinastic—so much so that in darkness the leaves curve downwards in opposition to diageotropism; when fully exposed to light the leaves are horizontal, the combined influence of diaheliotropism and diageotropism being sufficiently strong to counteract epinasty. Similarly, the young leaves of *Plantago* have been shown to be hyponastic—so much so that in darkness their hyponasty overcomes their diageotropism; the horizontal position assumed in bright light is the result of the co-operation of diaheliotropism and diageotropism in opposition to hyponasty.

The author is of opinion that these principles may be applied to the explanation of the various nyctitropic positions of motile foliage-leaves. Leaves which fall at night do so in consequence of epinastic tension; those which rise at night do so in consequence of hyponastic tension. The horizontal diurnal position of these leaves is due to the overpowering of epinasty or hyponasty by diaheliotropism and diageotropism acting together.

The paraheliotropism exhibited by some foliage-leaves, whether growing or motile, is referred to a special paraheliotropic irritability, the reaction under the influence of strong light being sufficient to overcome either hyponasty or epinasty, as the case may be, co-operating with diageotropism.

In conclusion the author refers to certain movements, such as the opening and closing of the leaflets of *Mimosa pudica*, and of the perianth-leaves of many flowers, which are induced by variations in the intensity of light. He concludes from his observations on *Helianthus*, &c., that the position assumed by dorsiventral members in darkness is that which indicates their inherent tendencies of growth, and he infers that the leaflets of *Mimosa* and the perianth leaves of those flowers which close in darkness or in light of diminished intensity are hyponastic, whereas the perianth-leaves of flowers which open in darkness are epinastic. He points out also that the effect of light in inducing change of position in these leaves is quite independent of the direction of the incident light, and is determined only by its intensity. The leaflets of *Mimosa* and many flowers open in light in consequence of the induction of epinastic tension in hyponastic members; flowers which close in light do so in consequence of the induction of hyponastic tension in epinastic members. These are instances of true photo-epinasty and photo-hyponasty, as distinguished from the cases (*Cucurbita, Phaseolus*) in which Detmer thought something of the kind occurred; the essential difference being, that in the present cases light induces a tension which is precisely the opposite of that inherent in the leaf, whereas in Detmer's cases light merely rendered possible, by inducing phototonus, the external manifestation by growth of the inherent condition of tension of the leaves.

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3. *On some recent Progress in our Knowledge of the Anatomy of Plants.* *By* D. H. Scott, *M.A., Ph D., F.L.S.*

Anatomy in plants inseparable from histology; the finer histology, however, excluded from the present paper.

Work of Grew and Malpighi laid the foundations of vegetable anatomy in the seventeenth century.

Recent progress, especially since the publication of De Bary's work in 1877, the subject of this paper.

Classification of tissues. Anatomical, developmental, and physiological methods of classification.

The Dermal Tissues.—Discoveries of Westermaier, F. Darwin, and Haberlandt. Olivier's investigation of the primary and secondary dermal structures in roots. Roots as respiratory organs.

The Assimilating Tissues.—Effect of light on structure. Observations of Stahl and Pick.

The Mechanical Tissues.—Schwendener's principles not generally applicable to Dicotyledons.

The Secretory Tissues.—Relation of secretory sacs to laticiferous tubes. Functions of the latter. Development of intercellular secretory spaces.

The Vascular Bundles.—Bicollateral bundles and medullary phloëm. Plasticity of dicotyledonous structure.

Secondary Growth.—Its importance as a means of *renewal*, as well as of *increase* of tissues.

Erroneous view of De Bary and Van Tieghem as to the mode of action of extra-fascicular cambium. The development of phloëm-islands imbedded in the wood. Connection between anomalous structure and habit. Importance of the *pericycle*. Morot's investigations.

The vascular cylinder of the *root* a *bundle-system,* not a single bundle.

Annual rings.

Sieve-tubes.—Discoveries of Wilhelm and Fischer. Hypothesis that the companion-cells have a secretory function.

Sliding Growth.—Short vessels of Dracæna, all Kny's results confirmed.

Apical Meristem.—Importance of the apical cell as essentially a part of the embryonic protoplasm.

Origin of lateral roots.

Anatomy of the Algæ.—Discovery of sieve-tubes in brown seaweeds. Parker, Will, and Oliver.

Anatomy of the Mosses.—Presence of a distinct conducting system. Haberlandt and Vaizey.

Anatomy of reproductive structures in need of further investigation.

Importance of anatomical characters in *classification.* Urgent need of profound research from this point of view.

Methods.—Further advance to be expected from the adoption of more perfect means of investigation, as in zoology.

Hopeful future of anatomy in union with physiology and general morphology.

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4. *On Botanical Gardens for Elementary Schools.* *By* PHILIP SEWELL.

With a view to facilitate botanical study, Mr. Sewell gave details as to the construction of small botanical gardens in connection with Merchiston and other private schools near Edinburgh, a Board-school at Dunfermline, and an 'Institute for the People' at Morton, near Manchester.

He showed that the cost in each case was trifling, and also gave hints as to the best methods of laying out these gardens, and as to the choice of plants.

The possible industrial value of practical botanical teaching in connection with horticulture was hinted at; but Mr. Sewell's chief point was that such gardens might serve to arouse an interest in the elementary study of science.

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5. *The Protection of Buds against the Sun.* *By* M. C. POTTER, *B.A.*

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6. *The Biology of Erythrina Lithosperma.* *By* M. C. POTTER, *B.A.*

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7. *On the Effects of Root-section on the Vitality of Pasture Plants.* *By* Professor W. FREAM, *B.Sc., LL.D., F.L.S.*

In the course of some investigations into the herbage of old grass lands which the author carried out last year, turfs nine inches in depth were dug from a number of old pastures in England and Ireland, and transferred to one and the same place, where they were planted to permit of growth and observation. The species growing upon each turf were identified, and, after careful separation, the specific constituents of the herbage were severally weighed, and the results tabulated. In the discussion that followed the publication of the results, it was argued that certain grasses, conspicuous by their infrequent appearance and small percentages on these turfs, had been killed by cutting at so 'shallow' a depth as nine inches. Whilst admitting the established fact that certain plants send their roots to a considerable depth, it appeared to the author that some confusion had been made between root-range, on the one hand, and the effects of root-section, on the other. To settle the point at issue, the following plants were selected:—

Alopecurus pratensis, L.—Meadow foxtail grass.
Avena elatior, L.—False oat-grass.
Dactylis glomerata, L.—Rough cocksfoot grass.
Elymus condensatus.—Canadian bunch grass.
Festuca pratensis, Huds.—Meadow fescue grass.

Phleum pratense, L.—Timothy grass.
Trifolium pratense, L.—Purple or meadow clover.
Medicago sativa, L.—Lucerne.
Taraxacum officinale, Web.—Dandelion.
Achillea Millefolium, L.—Milfoil or yarrow.
Plantago lanceolata, L.—Ribwort or plantain.

These plants were dug up in early spring, their roots were well washed, and then the roots and root-fibres were cut through with scissors at various depths below the surface. Several specimens of each plant were taken, and the length of root after cutting never exceeded three inches, and sometimes was as little as one inch. The various specimens were then planted out in poor soil, and they not only lived, but in the course of the summer they all came into bloom. This test was far more severe than in the case of the nine-inch depths of turf, where there was no transplanting in the true sense of the word. *Elymus condensatus* and *Medicago sativa* are not British pasture plants; but the former was employed because it is a grass far more robust and of much stouter roots than any British grass; its roots were severed at a depth of between 1½ and 2 inches. The latter is a notoriously deep-rooted plant, and the section of its roots was made at a depth of three inches. The experiment shows that root-section, even of very deep-rooted plants, may be performed, without fatal results, at exceedingly moderate depths. The practical interest of the point at issue is that it underlies a subject of very great agricultural importance.

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8. *On a Monadine Parasitic on Saprolegniæ.* *By* Professor M. M. Hartog, *D.Sc.*

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9. *On Tuchungia, a new Genus from Central Africa.* *By* Dr. F. W. Oliver.

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10. *On a case of Mycorhiza.* *By* Dr. F. W. Oliver.

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11. *On Floral Contrivances in the Genus Thesium.* *By* Miss Ewart.

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12. *On the Development of a Sclerotium from* Botrytis. *By* Professor H. Marshall Ward, *F.R.S.*

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13. *On the recognition, by means of Microscopic Sections, of Woods dug by Mr. Spurrell from the Forest Beds of the Thames.* *By* Professor H. Marshall Ward, *F.R.S.*

SECTION E.—GEOGRAPHY.

PRESIDENT OF THE SECTION—Colonel Sir FRANCIS DE WINTON, K.C.M.G., C.B., F.R.G.S.

THURSDAY, SEPTEMBER 12.

The PRESIDENT delivered the following Address:—

GEOGRAPHY has not inaptly been defined as 'the science of distributions,' and from whatever aspect we view it, whether from a large and comprehensive basis embracing all the conditions which surround it as a science, or from the narrower limits of simple physiography, we find certain well-defined principles, or one may term them natural laws, pervading everywhere, whose actions have, through their influences on the past, created the present, and according to the uses we now put them must largely govern the future.

The formation of our globe, unfolded to our vision by scientific discovery, brings us face to face with Nature in all her awful grandeur; and we learn how, under a beneficial and all-wise Providence, this world has been fashioned and made for the use of man during periods of time almost beyond man's calculations; and in the history of man upon earth—a mere drop in this ocean of time—we read of the rise and fall of nations, of great wars, of the discoveries of new routes (so ably described by my friend and talented predecessor in the address delivered by him in Section E. last year), and we see what large and important developments have taken place as regards the commerce and trade of the world by the effect of these influences; and then, turning to more recent days, we enter upon the discovery of steam, and its application as a motive power,—a discovery which has given rise to extraordinary changes—changes by which the whole trade of the world and its industries have been stimulated and promoted. Add to this the inventions in electricity, by which almost instantaneous communication has been established to all parts of the globe, and we may well cease to wonder at the increase that has been manifested in what may be termed the motive power of the world, and the development of its larger activities.

Still the natural laws which govern this globe, in their relation to the science of geography, remain the same. It matters not how rapidly you travel from the pole to the equator, you will freeze at the one and perspire at the other; and while passing through the different zones of temperature lying between these regions—the frigid, temperate, and torrid zones—you will find each with their own products, varying with climate, soil, and peculiarity of position, and these variations pervade the whole realm of nature. Take man as an example: with all his power of brain and reason, he is largely subject to his environment. Look at the toiling millions of the temperate zone, and the enormous activity they display, both mental and physical. Note their colour, form, nervous development; and then pass into the tropics, and the whole creature is changed: he is different in colour, and displays none of the energy or brain-power of the white species of his kind. Why is this? It is chiefly due to the environment in which the creature is living.

The effect of climate upon race is somewhat remarkably illustrated in recent times by noticing the physique and nerve-power of the present race of Americans.

The wonderful tide of emigration which has raised them to being a nation of 60,000,000 people may have exercised certain influences as regards this change; but there are many true Americans still in existence. Two hundred years ago they were the same race as ourselves, but the difference between us now is marked. The climate of America has given them an individual stamp, and a perceptible difference in outward semblance has shown itself even in this short space of time.

Similar changes are manifested throughout the whole animal and vegetable kingdom; and while the geologist, zoologist, botanist, ethnologist and entomologist, each and all are separate branches of science, yet each and all have a common ground in geography and its application to the shape and form of land and sea; to the wrinkled folds of the earth's surface which we call mountains and valleys; to the mighty ocean with its currents of air and water, and the influences they exert; to the huge inland seas and lakes; to the great rivers and small streams; to the endless varieties in the animal and vegetable kingdoms; and we find these great elements of nature contributing each in its own sphere to questions relating to the commerce of the world and the development of new countries.

In this brief introduction to my paper I have designedly, though very briefly, drawn your attention to the science of applied geography before passing in review the most recent explorations and discoveries of the present day; and while doing this, I shall endeavour to draw attention to the great necessity for a more thorough study of this science, and the influences it exerts upon trade and commerce, as we gain a better knowledge of the products of one country and the industries of another, as well as the importance of such knowledge to the great manufacturing centres of this nation as new countries are discovered and developed.

It must be remembered we no longer enjoy a monopoly of trade. Other nations are exhibiting large commercial activities; and if we desire a continuance of the trade of Great Britain we must put our shoulders to the wheel with the same energies and creative power that have produced such astonishing results during the present century.

In the paper to which I have already alluded it was clearly shown how largely the rise and fall of the great emporiums of commerce in past centuries were influenced by the struggle for the Eastern trade. This struggle is still going on. The Russians in Central Asia are steadily advancing as each year goes by, and developing that system of absorption which has characterised their policy, especially in that region. Central Asia is the chosen field of their explorers, and the recent decease of General Prejevalsky has been a great loss in the scientific world. A full account of his remarkable discoveries and explorations appeared in the 'Proceedings' of the Royal Geographical Society.

The principal work accomplished by the latest Russian explorers, Messrs. Grombchevski, Mr. Lidsky, and Mr. Grum-Grijmailo, in Central Asia have been in the region of the Pamir, and thence across the Hindu Kush into Hunza. Also in Eastern Bokara and in the upper waters of the Yarkand River, the Kalik Pass, and Kanjat. In the prosecution of these researches, which are all dangerously near our Indian frontier, very full reports are made, more especially as regards trade and commerce; and there is no doubt, since the completion of the Transcaspian railway to Samarcand, a great impetus has been given to Russian trade in Central Asia, even extending, by well-known routes, as far as the north-west provinces of China, where Russian goods are now found entering into competition with those of English manufacture.

By means of this railway, right into the heart of Asia, Russia has obtained the trade of a vast area, which formerly passed entirely through British hands. Both politically and commercially she is our rival in the East, and the question which nation is to be supreme must come sooner or later.

There is no more interesting country in the world than China. Her teeming and industrial population, her large mercantile centres, the geographical situation of her territory, her undeveloped mineral wealth, her individuality, and the magnitude of her trade with this country, all combine to invest her with a peculiar importance as regards our mercantile community. Coal has been dis-

covered in all the seventeen provinces of the Chinese Empire, but the passive resistance offered by her rulers and her peoples to all attempts by foreign nations to obtain a footing in the interior has prevented any development of her resources. The day, however, cannot be far distant when railways, some of which are already projected, will open up the interior of China and make her better known; but we should be unworthy children of our forefathers if we permit the trade of this rich and widely-peopled country to pass from our hands, either from a want of energy, or from a departure from those principles of trade and commerce whose foundations are built upon the rocks of integrity and honest dealing. Nothing marks the individuality of the Chinese more than that, wherever you meet him, whatever his surroundings may be, he is John Chinaman still; he never adopts the dress, manners, or customs of other nations, but he remains constant to the pigtail, the quaint dress, and the umbrella; and if established in communities, you will find him with his joss-house, food, theatre, and his refreshment-places just as if he were in China.

Our knowledge of the latest acquisition in the East, Burmah, has been largely increased during the past eighteen months. Important surveys in North Eastern Burmah by Colonel Woodthorpe, R.E., and Mr. Ogle have opened up an area of about 1,500 square miles; and the fact of practicable routes between Assam and Burmah *viâ* the Palka Pass is now established. Burmah, with its large and intelligent population (numbering about 4,000,000), with its valuable minerals and precious stones, with its tropical products, is well worthy of the attention of the merchant adventurer; and as our knowledge of the physiography of the country is rapidly increasing, a study of its applied geography is strongly recommended to the student.

In our own territory of British India large and important surveys have been carried on under the able direction of Colonel Thuillier. These surveys are conducted in what is called the protected region; but very interesting additions, especially to the merchant, are made in the outlying territories bordering upon our Indian Empire, where no white man could go, by the employment of intelligent natives especially trained for the purpose. The information obtained by these men may be very profitably studied.

These Central Asian problems are full of deep significance to those desirous of developing and retaining the supremacy of the trade of this Empire in those regions; and I am happy to state that papers full of interest on these subjects will be presented to you during this meeting.

Turning to the northern parts of Asia, I feel some diffidence in speaking before a Newcastle audience on the subject of Siberia, for through your own townsmen, and Captain Wiggins, you are well acquainted with these regions. The exertions made by Captain Wiggins and those connected with him in this enterprise should receive the highest commendation; and that they have been so far successful is a matter for rejoicing. At the same time, I cannot but think that Russia, continuing the policy she has so steadily pursued for some years past, against the commercial development of Great Britain, would not object to the employment of British capital in opening up trade in her outlying dominions; for that trade, once fairly established on good business lines, would be absorbed on behalf of her own manufacturers. I do not attach any blame to Russia in this matter, but I am of opinion that more profits are to be gained when trade follows the flag, for then British enterprise and money reap more certain reward. If the energy, talent, and perseverance which have been exhibited by Captain Wiggins and his partners had been utilised in the development of some of our own territories rather than in the territory of another nation, I feel sure they would command that success to which they are so justly entitled.

From the consideration of Siberia and the Northern Seas it is not a far step to Greenland, whose icy regions and eternal snows have been crossed for the first time in our history. The hero of this exploit, Dr. Fridtjof Nansen, is a native of Norway, and the exploration which he has so recently conducted to a successful issue was rightly alluded to by the President of the Royal Geographical Society, in his annual address, as the most conspicuous achievement of the year.

Though young in years Dr. Nansen proved himself to be a leader of men, and the account of his adventures will be found to be full of interest. The results of his expedition deal rather with the world of science than with commerce, as his discovery proved Greenland to be nothing more or less than a continent whose interior is a huge region of ice and snow. It, however, presents a most interesting study to those desirous of advancing our knowledge of glaciers and the glacial period. Dr. Nansen's description of this immense mass of frozen snow, forcing its way coastwards from the higher plateaus of the interior, by sheer weight and pressure, grinding, crushing, resistless in its slow but ever-moving power, gives one a faint idea of how the hills and valleys of the world were formed when, in remote periods of time, they too were under glacial influences.

Crossing from Greenland to North America, we still find ourselves in regions where ice and snow hold undisputed sway for a considerable portion of the year. The Canadian Government, with commendable activity, keep pushing forward their surveys into what is known as the Old Hudson Bay Territory. The Mackenzie River has been found to be a far larger body of water than formerly supposed. More accurate surveys as regards the size of some of the great lakes of those regions are being made, and our knowledge of the climate and the isothermal variations of British North America is each year increasing.

Petroleum has been discovered, and, as the geological surveys advance, other discoveries of an important nature may reasonably be anticipated. I have been told of the existence of a huge bed of porous sandstone, saturated with mineral oil, which burns like coal.

Moving southwards, we pass through the prairie-lands of the North-West of Canada, traversed by the Canadian Pacific Railway. These rich lands are being rapidly developed, and should form a happy home for some of our surplus population. Colonisation is a subject full of geographical considerations, but it demands a special paper, and I have neither space nor time to introduce it into this address. At the western edge of these prairie-lands are the Rocky Mountains, in whose foothills are now being reared large herds of cattle and horses, as well as flocks of sheep. Some cattle from these fertile regions were shipped last year to the English market, and no doubt a regular trade will soon follow this experiment.

Crossing the Rockies in a westward direction, you come to the Selkirk Range, then to the Gold Mountains, and lastly to the Cascades, whose wooded rocky sides plunge into the Pacific. Constant explorations are being carried on through these mountain ranges, chiefly in researches after gold and other precious metals, and our knowledge of their physiography is rapidly increasing. The Rev. Mr. Spottiswood Green, in an interesting paper concerning these regions, tells us something of the configuration of the Selkirk Range, which offers alike to the mineralogist, sportsman, and Alpine explorer a field of great interest.

Continuing southward, we pass through the fertile plains and valleys of California, whose large industries in grape and orange culture are being fostered and developed. And from California you enter into Mexico, whose wonderful mineral resources are receiving a new impetus by the construction of railways, 4,700 miles of which are now open to traffic. These railways will not only facilitate the transport of the wealth of Mexico from the coast to the sea, but they tend also to promote law and order among its restless and lawless population.

As law and good government are established, so will trade and commerce and the natural riches of the country be promoted and encouraged.

Crossing over to South America, we find considerable progress in commercial activity, chiefly due to the increased means of communication.

In the smaller republics upwards of 1,500 miles of railway have been recently constructed; while in the larger states, Brazil has 6,000 miles; Peru, 3,000 miles; Chili, 1,630, and the Argentine Republic, 4,700; making a grand total in South America of nearly 17,000 miles of railways. This allusion to railways may not be considered as bearing on the science of geography; but railways are very important factors as regards the commerce and trade of the world, and by the facilities they afford they largely increase the power of exploration.

The southern portion of South America has been described by those who have

visited and explored its savannahs and prairie-lands as possessing one of the richest grazing-lands of the world, and its development is only a question of time. In its present condition it offers a very interesting field of research to the explorer.

Time does not permit us to dwell long on the islands of the Pacific. Recent events concerning Samoa are fresh in your memories; and while some of these islands have developed commercially, it is when they lie in the great ocean tracks of the world that their real importance is manifested. Take for example the island of St. Vincent, of the Cape Verde group. It is nothing but a barren rock, without any produce whatever; all its water has to be brought from a neighbouring island; yet it pays a large revenue to the Portuguese Government simply from coal dues, for it has a good harbour and lies directly in the line between Great Britain and the principal ports of South America; it has therefore become a most important coaling-station.

From the isles of the Pacific it is but a step to Australasia, with its six great colonies of Queensland, Victoria, New South Wales, South Australia, Western Australia, Tasmania, to which may be added New Zealand. Virgin fields untrodden by the foot of white man are still awaiting the explorer to yield up their treasures to the science of applied geography; and when the marvellous progress that has been made in a few short years by our Australian Colonies is weighed and considered, and as its vast interior is opened by exploration, and its mineral resources are developed, who could venture to predict the future that lies before it?

There are now nearly 11,000 miles of railway in operation, and many more miles are in course of construction throughout these various colonies—a sure and certain indication of their energy, wealth, material prosperity, and progress. Geographically speaking, some are not without their troubles. Take Queensland for instance. Her territory runs north and south for nearly 1,500 miles, and lies both in the temperate and tropic zones. The Governments who during past years have administered her affairs have experienced some difficulties whilst endeavouring to reconcile the conflicting interests which arise out of her geographical position.

Laws relating to labour and capital in a temperate zone are not always in conformity with the industries and requirements of a tropical temperature, in which the white man is obliged to employ labour suitable to the climate. Hence we find a numerous section of the inhabitants of the northern part of this colony agitating in favour of separation. Australia has large coal-measures, and abounds in precious metals as yet hardly developed.

Attached to Australia are the great and lesser islands forming the Australasian archipelago. The most important of these is New Guinea, and quite recently a successful exploration of its highest mountain range has been accomplished by the present administrator, Mr. Macgregor, who reached an elevation of about 14,000 feet. A very interesting paper was read before the Royal Geographical Society by Mr. Paul Thomson concerning the D'Entrecasteaux and Louisiade groups, adjacent to New Guinea; and though many of these islands and their inhabitants are quite new to us, still the knowledge we gain from a study of their geographical position may be turned to practical uses by the merchant adventurer.

Last but not least in this record of geographical progress of the world is the vast continent of Africa.

As General Strachey, late President of the Royal Geographical Society, in his address of this year, remarks:—

'The reflection can hardly be avoided that, great as has been the advance of exploration in Africa during the last twenty or thirty years, the interest of geographers will, in the immediate future, be more and more centred in that continent. Excluding the polar regions, there is no considerable portion of the earth's surface, unless it is in Africa, the essential outlines of which have not been delineated.'

These words are, I think, absolutely true. Whether we consider Africa in regard to the extraordinary explorations and developments since the commencement of the work of David Livingstone; or from the fact that vast areas of its tropical portion still remain untouched as yet by exploration, and are therefore unknown; or from a contemplation of the teeming millions of its inhabitants, of which the larger portion have never seen a white man; or from the uncompleted work of the late

General Gordon, and the re-establishment of a civilised government over the whole of the Nile basin; or from the slavery question, in which our nation has taken the most active and leading part; or from the spectacle of a white man, Emin Pasha, establishing a settled form of government in the heart of the continent, between the two great slave-dealing communities of the Bahr-el-Ghazal and that of the Upper Congo and Lake Tanganika; or from the expedition sent to convey to him the succour he so much needs, under the leadership of Mr. H. M. Stanley; or from the intense interest recently exhibited by the nations of Europe in portioning out Africa between each other—an interest that has led on the west coast to the establishment of the Congo Free State, and the German protectorate in the Cameroons, France and Portugal adding largely to the possessions they already hold, and England contenting herself with strengthening her grip upon the Niger, and on the east coast by the formation of the British and German spheres of influence; or to the colonies which Great Britain possesses in the southern extremity of this great continent; or to the struggle which sooner or later must be fought out between Christianity and Mohammedanism as regards the native races of Central Africa, in which the river Congo will play an important part: I say when we consider all these and the many other problems of this continent, the vast interests they represent, and the varied influences they may yet exert on the future history of this earth, as well as the extraordinary part which Great Britain has been permitted to play in lifting the veil of mystery and doubt which up to our own times enveloped these regions, we are forced to acknowledge that the country in which the civilised world takes the most active and absorbing interest is Africa, and that the Dark Continent still maintains its supremacy.

As regards Africa two very remarkable journeys have recently been brought to a successful conclusion—that of Count Teleki, an Austrian, on the north, and that of Mr. Arnut in the regions south of the equator.

The former, entering Africa at Mombasa, at the head of a numerous and well-equipped caravan, passed through the Masai country by what is known as Thompson's route, and, pushing northwards, discovered Lake Rudolph, a large inland salt lake, and by following its shores he was enabled to trace with commendable accuracy its shape, size, and position. The existence of a large lake, called Samburu, in the direction of Count Teleki's journey, had for some time been spoken of by the Arabs who traded in that region, but nothing definite was known concerning it. Count Teleki also obtained much valuable information of the region between Mount Kenia and Lake Rudolph, its inhabitants, its rivers, and its products; and the details of his most interesting and successful journey have yet to be published.

Mr. Arnut, on the other hand, started in 1883 from Pietermaritzburg with a very slender equipment and hardly any following. His object was to prove the existence of healthy plateaus in the interior of Africa where white men could live and prosecute the work of missionary civilisation without being exposed to the malarial influences which exist in so many parts of Central Africa.

Taking a northerly course, he reaches the Zambesi, whose waters he follows as far as Lealui. From this point his route trends to the west as far as Robongo, the capital of the Bihe country. From Robongo he continues his march to Bailundu, and thence he reaches Benguela, on the west coast. Thus he crossed Africa in the same direction as Livingstone's first journey, though somewhat to the south of Livingstone's route. While at Bailundu he meets some messengers from Msidi, the chief of the Garengenze country, who beseech him to visit their king; and having replenished his stores, he retraces his steps to the interior.

From January 1885 to February 1886 he perseveres in his attempt to reach the capital of Msidi's country, and his efforts are at length crowned with success. After a sojourn among these people for two years, during which time he thoroughly succeeded in obtaining their confidence and that of their ruler Msidi, he returned to Europe in the latter part of last year, but not before he had established two other white missionaries at Mukururu to continue the work he had begun.

He also made several small expeditions during his residence at Mukuru, the most interesting of which was to the cave-dwellers of Urua mentioned by Living-

stone. This kingdom of Garengenze is situated to the east of Lake Moero; and Mr. Arnut has recently published a book of his travels, giving a very clear and interesting account of these people, their manners, and their customs. Of all Livingstone's followers, Mr. Arnut very closely resembles the great leader in the patient earnestness, the quiet energy, and the scanty resources with which he prosecuted his remarkable journeys.

He has quite recently returned to the west coast of Africa with the intention of rejoining his friends at Garengenze.

The events which attended the expedition under Mr. H. M. Stanley to succour and relieve Emin Pasha are so well known to you all that I shall only attempt a brief recapitulation here.

We have learned from his own pen how, after much suffering and great hardships, he eventually overcame all the difficulties and obstacles which had to be encountered while conducting his caravan from the head waters of the Congo to the lake Albert Nyanza; that on reaching that lake he met Emin Pasha.

. . . .

The value of Mr. Stanley's journey and the remarkable energy and courage he displayed, his high scientific attainments, and the information that will result from his labours, are, from a geographical point of view, of the highest interest. The desiccation of the lake Albert Nyanza, and its influences on the rise and fall of the Nile, are not the least remarkable of these problems. For my own part, I am of opinion that this rise and fall is mainly caused by the rapid growth of tropical water-plants. During the dry season this vegetation increases enormously, and at the first rains large masses of aquatic growth are loosened by the rising of the waters. These masses, in the form of floating islands, pass downwards on the bosom of the flowing waters, and on reaching a wide and shallow part of the river, such as we find at the Bahr-el-Ghazal, they gradually but quickly collect till they form a dam of sufficient density to obstruct the progress of the river; and the water thus arrested finds a temporary lodgment in the lake of Albert Nyanza, causing it to overflow its normal boundaries. At length the vegetable dam can no longer withstand the weight and pressure of the water bearing upon it; a portion gives way; a channel is opened; and the river, hurrying on to the sea, overflows the banks of the Lower Nile and drains the lake to a lower level. This is what happens to the Albert Nyanza, which is nothing more than a huge backwater of the Upper Nile basin, and it accounts for the lake being seen at two different levels by those two distinguished explorers Mr. H. M. Stanley and Sir Samuel Baker, and hence the difference of opinion as to its true extent and size that has arisen between them. We know that this phenomenon takes place on Lake Tanganika, as Stanley found a marked difference in its level on the two occasions he rested upon its shores. He also followed the Lukuga River from the Tanganika lake to its junction with the Congo; and there is no doubt that a vegetable dam, such as I have described, forms at the point of departure of this river from the lake, and prevents its regular flow till the weight and pressure behind it sweeps all away. During the second year that I was on the Congo we had an unusually heavy flood at the time of the first rains. The river rose several feet in one night, and some months afterwards news came from the Upper Congo that the waters of the big lake had broken through, and this no doubt had reference to the Lukuga River and Lake Tanganika.

Now, as regards the countries through which we have been passing, there are certain points of great interest connected with the science of applied geography, to which I desire to draw your special attention.

The first of these points is the study of the great railway systems of the world, and the application of railways to the development of new countries. Take our Indian possessions for example. What a change has been wrought, not only as regards the commerce of the country but also with reference to the social condition of its inhabitants and their manners and customs! The introduction of Indian wheat, by means of these railways, into the markets of Europe has caused a revolution in the trade of that commodity. We find this especially in America, where it has upset the calculations of those gigantic combinations or rings which sought

to obtain a monopoly in the supply of this universal article of food. Thus the construction of railways in the East exercises commanding influences over the markets of the West.

Consider also the traffic from China and Japan to America, with its 60,000,000 people, by means of the great Atlantic and Pacific railways, in tea and raw materials. Now, although railways cannot compete with direct traffic by sea, when the necessity for more rapid conveyance of certain goods arises, we find that a combination of sea and land transport is often adopted in preference to the longer route by sea alone.

The development of any country, no matter what its geographical position may be, is enormously increased by the construction of railways. Take the Congo Free State as an instance (which is undoubtedly the finest property in Central Africa). So long as the Upper Congo region, with its miles—measured by thousands—of navigable tributaries, was separated from the Lower Congo by the rapids extending from Stanley Pool to Matadi, this magnificent territory was practically shut to trade and commerce. Every piece of goods in the interior had to be carried on men's heads for more than 200 miles, and all ivory and other products were brought to the coast in the same way. Roughly speaking, such transport costs about 40*l.* per ton.

The Congo Free State has wisely determined to build a railway, of some 250 miles in length, to cross this cataract region; and the moment it is completed the future of that country is assured.

H.M. the King of the Belgians has kindly given permission for a Belgian officer of distinction, Captain Thys, to read a paper at this meeting on this railway, which will afford a more detailed account of this wise and patriotic undertaking.

I have mentioned railways as the first point of interest because they are creations of our own time, and have therefore a special interest of their own; but the most important factor in the early history of the science of applied geography, and to which the establishment of our great colonial empire is mainly due, is the record of the Merchant Adventurers.

Their voyages and exploits, extending to every part of the globe, began at the end of the fourteenth century, in the reign of Henry VIII., when the Cabots (Venetians) sailed from England to Newfoundland, and afterwards to Florida. This expedition and those which followed it were fitted out at the expense of corporations of merchants, with the object of extending the commerce of the country by a search after trade in new and foreign lands. They were placed under the command of some well-known leader, and the results obtained were extraordinary.

In 1530 the Merchant Adventurers of England attempted the North-west passage, as it is called, to China, and between 1550 and 1578, Sir H. Willoughby, Frobisher, and Sir H. Gibbon all made remarkable voyages.

Between 1585 and 1615, Davis, Hudson, and Baffin were sent by merchant companies to the polar seas, and their discoveries are handed down by the straits and bays which they discovered, and which bear their names.

In 1580 Drake took the first English vessels into the Pacific Ocean. Drake was not only a bold and successful navigator, but he was also a commander of men, in which he showed rare tact and ability.

In 1588 the merchants of Exeter established a trade with the West African coast, and the Senegal Company was formed.

In 1553 the first effort to reach India was made *viâ* the Cape of Good Hope. It was not, however, till the year 1660 that any progress was made in the East. In that year the East India Company was formed, and it is to the establishment of this Company that we owe our great Indian Empire. The year 1669 saw the formation of the Hudson Bay Company—a company which exists at the present day. And so the record goes on down to our own times. Not the least amongst the trading corporations of Great Britain were the Merchant Adventurers of this city in which we are now assembled; and they too contributed in no small degree, not only in the past but in the present, to the extension of our geographical knowledge and its application as a science. No doubt the spirit and energy of our Scandinavian forefathers has been fostered and encouraged until it has now found its development in the enter-

prise and prosperity of this great mercantile centre of the north of England. And the old churches of Jarrow and Monkwearmouth bear further testimony to the fact that, as commerce drew together communities which became centres of maritime energy and progress, religion was not forgotten, and the seed of knowledge and truth thus sown in the early history of the past has spread itself throughout the length and breadth of the great colonial empire of Greater Britain.

Following on the discoveries of the sixteenth and seventeenth centuries, and the marvellous results to which they have given birth, the story of our own times, from a geographical point of view, is quite as wonderful. As I remarked at the beginning of this paper, the discovery of steam as a motive power has brought the world into an extraordinary condition of contactiveness, and quite recently several new companies have been formed in the same spirit and on the same lines as those followed by the old Merchant Adventurers. These later creations are being started under more favourable conditions than their predecessors, for they have all the advantages which modern science and modern appliances can afford. The English Government have wisely encouraged and promoted the formation of these trading corporations. In countries where climate and circumstances of environment are not favourable to colonisation by white men, our colonial system of government progresses somewhat slowly. It has not the elasticity, nor the adaptability, to provide for the many contingencies which must naturally arise when a few white men maintain the position of rulers over large areas peopled by savage and uncivilised races.

In the island of Borneo there is the North Borneo Company trading, governing, and civilising a large portion of territory with marked success.

On the west coast of Africa, the Royal Niger Company is developing the great natural resources of that magnificent river, and its tributary the Binue.

On the east coast there is the Imperial British East African Company, operating in what is known as the British sphere of influence north of Zanzibar. Though not a twelvemonth has passed since they commenced their work, their initiatory proceedings have been remarkably successful, and there is every prospect of an early and rapid development of the territory committed to their charge. In the south-eastern portion of Central Africa, the African Lakes Company have fairly established themselves; and a new company is now being formed to open up and civilise a further portion of that section of the African continent.

The establishment of these great trading and governing centres is likely to exercise most important influences. They are, as I have before pointed out, from their organisation and objects, better adapted at the outset to compete with and overcome the obstacles which present themselves to established forms of bureaucratic government; at the same time the Government of this country can interfere, in cases of necessity, by the grants that have been made to them of royal charters, under which they carry on their operations.

A wise control and judicious administration combined with the introduction of commerce and civilisation will, at no distant date, open these territories to the markets of the world, to the missionary, and to the scientific explorer. The commercial element of geography also enters very largely into their promotion and prosperity because of the fields they open to our home manufactures. It is important here to observe that, if these territories had passed into the hands of other nationalities, but a very limited quantity of British goods would ever have entered into them, and their value, as a market for the industries of the nation, would have been lost.

The establishment of a Geographical Society in this city is of real importance. Its objects should be the collection of information, and the study of applied geography in all its varied branches and aspects. It should aim to furnish complete information concerning the geography of all parts of the globe. In Chambers of Commerce our large trade centres have, no doubt, means of guiding and controlling some of our most important mercantile operations, but they afford no opportunities to the student, they are not a teaching body; and there are instances where considerable risks have been incurred and heavy losses sustained in some of their ventures, simply from a want of knowledge of geographical data.

I should like to see a Geographical Society in every large city of this Empire, conducted on the lines I have briefly suggested, because the study of, and interest in, the commercial geography of this great Empire and the world is too much neglected amongst us. Past prosperity, and a tendency to run in the same groove, narrow our commercial horizon. Slowly but surely other nations, competing with us in many parts of the world, are doing so successfully because of the study they make of commercial geography.

It is for this reason I have in my address dwelt strongly upon the question and study of geography as an applied science, and it is for a greater reason I urge its importance, viz., that we may hand down to our children unimpaired the heritage bequeathed us by our forefathers; a heritage gained by courage, energy, perseverance, and patriotism—qualities which, under God's blessing, have made this nation the head of the commerce of the world.

The following Papers were read:—

1. *Cyprus.*[1] *By* General Sir Robert Biddulph, *G.C.M.G.*

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2. *The Congo Railway.*[2] *By* Captain Thys.

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3. *The Physical Basis of Commercial Geography.* *By* Hugh Robert Mill, *D.Sc., F.R.S.E.*

A necessary preliminary to the study of commercial geography is a full acquaintance with topography, especially with the names and positions of all commercial towns.

A necessary accompaniment to the study of commercial geography is a knowledge of the ever-varying relations between regions of supply and demand, the incidence of tariffs, and the political and social conditions of countries.

The physical basis of commercial geography, which underlies and gives unity to the whole subject, is a knowledge of the resources of the earth as regards the various existing forms of matter and modes of energy, the best means of separating, combining, and modifying these so as to produce commodities, and the way in which commodities can be best transported. Commerce being the artificial redistribution of the matter and energy of the world, a knowledge of the general properties, and the unchangeable laws of matter and energy should take a chief place in the training of commercial men. A general acquaintance with this practical science, which may be termed *Applied Physiography*, or *Practical Earth Knowledge*, ought to be possessed by all merchants, and a special branch should be familiar to each. Amongst the advantages which would thus be gained are:—

(1) The merchant would understand the principles of the production and manufacture of his goods.

(2) He would know in many cases, without aimless and extravagant experiments, where it is possible to produce any special commodity in great abundance.

(3) He could, to a great extent, anticipate the frequent changes in staple commodities by knowing what other commodities it is possible to produce in the regions now yielding the staple only.

(4) He would understand the best and shortest routes between trade centres.

Illustrations and arguments showing the importance of these statements were given in the paper, and a large map of the commercial development of the world was shown.

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[1] Published in the *Proceedings of the Royal Geographical Society*, December, 1889.
[2] See *Proceedings of the Royal Geographical Society*, October, 1889.

4. *Buganda (Uganda). By the* Rev. R. P. Ashe.

Geographical investigation includes much more than the merely physical features of any country. Speke's discovery of the source of the Nile was hardly so wonderful as his bringing to light the nations and kingdoms about the shores of the Victoria Nyanza. Events of recent years add a deepening interest to Buganda. The author referred, among other matters, to Livingstone's death, Stanley's travels, the Nyanza mission of the Church Missionary Society, Gordon's death, and Stanley's effort to relieve Emin (surviving Egyptian pasha); the English and Germans competing for this market for European manufactures, and key to the lake regions. The author then went on to describe the great lake and its islands; tropical forest scenery; the contrasts between Buganda and districts further south; the nature of country; the products of the soil; roads; villages; buildings.

As to the people, the author pointed out that the non-negro element is derived from the royal Bahuma (Wahuma) tribe. He then described the Bahuma; referred to the great native, slave, and cattle raids; the organisation of the Buganda people, kings, chiefs, peasants, slaves, manners and customs. He then spoke of the African problem; the Arab trader; slaves; ivory; guns.

5. *The Commercial Geography of Yoruba, West Africa.*[1] *By* His Excellency Governor Moloney, *C.M.G.*

FRIDAY, SEPTEMBER 13.

The following Papers were read:—

1. *On the Great Central Asian Trade Route from Peking to Kulja and Semirechensk, and to Yarkand and India. By* Colonel Mark S. Bell, *V.C., R.E.*

Kashgaria is reached from Peking by the Ala-shan or, generally speaking, desert camel route, *viâ* Kwei-wha-cheng and Barkul, and the Wei Valley route, a cart road leading through Pau-ting-fu, capital of Chili; Tai-yuen-fu, capital of Shansi; Si-nan-fu, capital of Shensi; Lan-chow-fu, that of Kansuh and Hami, crossing the Gobi desert between An-si-chow and this latter place. The route would be classified by the Chinese into stages as below, and would be each assumed to take eighteen days of travel—*i.e.*, Peking to Tai-yuen-fu, 375 miles; Tai-yuen-fu to Si-nan-fu, 438 miles; Si-nan-fu to Lan-chow-fu, 449 miles; Lan-chow-fu to Su-chow, 482 miles; Su-chow to Hami, 418 miles; and thence onwards, Hami to Hung-miot-za, 408 miles; Hung-miot-za to Ili, 400 miles; Hami to Karashahar, 420 miles; Hung-miot-za to Karashahar, 256 miles; Karashahar to Aksu, 373 miles; Aksu to Kashgar, 311 miles.

Few Europeans have traversed this route since the days when the conquests of Ghenghis Khan and his successors opened Asia to the inspection of Christendom, and none have done so in its entirety since the Mahammadan rebellion in the north-west of China before 1887, when the reader of this paper did so.

After describing the route through Shansi to Si-nan-fu and touching upon lateral communications and the mineral and agricultural resources of the districts traversed, the commercial importance of the Wei Valley is dwelt upon, and it is shown how this centre of gravity and of resistance of Mid-China is cut off from the rest of the empire by mountainous or hilly regions at present most difficult to traverse. The routes possible to be followed by railways are reviewed, and the necessity of this

[1] See *Proceedings of the Royal Geographical Society*, October, 1889.

rapid communication to China, if she desire to retain possession of her north-west provinces and Kashgaria, is pointed out. From Si-nan-fu the route turns to the north-west and leaves the fertile loess valley of the Wei to traverse the once fertile but now devastated and depopulated hills and valleys of Shensi and Kansuh to the confines of the Gobi desert at An-si-chow. The description of the route which crosses passes elevated 10,000 feet is followed by that of the Gobi route to Hami. In conjunction with them are considered the lateral communications, resources of the district in coal, &c., and the inhabitants both of this wedge of cultivation held by the Chinese in the past as a means of gaining access into Central Asia, and of its lateral mountains and deserts. The importance of this bottle-shaped portion of Kansuh, the one and only natural route between the extreme east and the extreme west, as a means of communication between Central Asia and Mid-China, is pointed out, and its fitness for a railway route and its influence over such on our Chinese trade, discussed. From Hami the route over the Tian-shan to Barkul and through this range and along its northern *glacis* slopes to Hung-miot-za is described, as well as the falling away of this great range here, and the natural access that at this point exists between the Tian-shan-peh-lu and the Tian-shan-nan-lu, *i.e.* the two great historical routes from Hami to the north and south of the Tian-shan range. This section of the Central Asian trade route and of the Tian-shan range with its arid deserts and paradises of oases has not been previously described in detail.

An account of the Tian-shan-peh-lu and nan-lu is followed by a few remarks on the routes into Russian Turkistan and Ladakh from Kashgar and Yarkand. As China is of interest to Great Britain as a possible military ally in the future, and as a present certain and important commercial one, the study of the political geography of the country traversed by this most important cart route of the past and coming railway one in the future is a very necessary one to our Eastern interests, and requisite to enable us to foresee coming events and to mould them to our advantage. As an incentive to this study the paper on this trade route has been prepared.

A short summary of the various sections of the route as traversed is here given:—

From Peking the route runs over the great plain of Chili for seven days (218 miles) to Whailu, and thence for five days over the hills separating Chili from Shansi, about 130 miles broad and passing over heights of 4,500 feet to Tai-yuen-fu. This belt of hills, of loess, extends from the Nan-kow Pass on the Peking-Kalgan road in a south-west direction to the Yellow River, and is crossed by carts only at this crossing-point, and on the Tung-kwan, Honan-route, *i.e.* the Yellow River route. The hills are cut up into numberless ravines, and in them it is difficult to move anywhere off a few tracks. Shansi, now traversed, is rich in coal and iron, but does not grow enough grain for its own consumption. Between Tai-yuen-fu and Si-nan-fu the valley roads are similar to those over the loess hills, and a difficult range, at the Ham-sin-ling pass elevated 4,000 feet, is crossed between the Tai-yuen-fu and Ping-yang-fu basins. The roads are but deep gullies, 8 feet to 10 feet wide and 30 feet to 50 feet deep, for miles. They are practically suited for one line of traffic only; there is not a metalled road in the country. Shensi produces abundance of grain. For days around Si-nan-fu the traveller passes through one vast wheat-field. From Si-nan-fu, capital of Shensi, to Lan-chow-fu, capital of Kansuh, 450 miles, the road passes over a difficult, hilly country, over heights of 8,000 and 10,000 feet, and being during the greater part of the time at an elevation of 6,000 to 7,000 feet. The road is at times a fine highway, at others a deep gully; its inclines are steep; the greater part of the country is depopulated and its villages destroyed; a few of the walled towns have alone escaped the Mahammadan rebellion. No confidence has returned to the people, for it is fourteen years since the rebellion ceased and the land is still untilled; the Mahammadans, braver than the Heathen Chinee, are feared by them. These considerations give some idea of the present weak connection that exists between China and Kansuh. Between Lan-chow-fu and Su-chow, 482 miles, the road twice passes over heights of 8,000 to 9,000 feet by easy and gradual ascents and descents. For a part of this distance only it passes through a narrow strip of cul-

tivation; for the rest it runs over a barren plain or amongst low hills. An easy road through a very devastated country leads to An-si-chow, bordered by the Nan-shan Mountains and the desert occupied by Tibetans and Mongols; the Chinese occupy the narrow intervening strip, which consists of cultivated stretches, desert, and grazing grounds.

The Gobi for 200 miles is almost an absolute desert; water can, however, be readily obtained and is often close to the surface, and springs occur apparently at intervals of 20 to 30 miles in any direction. The route could be readily stocked with grass from Hami, but carters prefer to carry chopped straw and grain. The water is brackish but wholesome. At Hami, a rich oasis of no size, the two cart ruts from Si-nan-fu open out into four, two going to Kulja, 800 miles, and two to Kashgar, 1,200 miles. Here also a good camel road joins in from Peking, distant by it 1,255 miles; it passes through desert chiefly to Kwei-hwa-cheng, and supplies have to be carried.

Barkul, the Chinese Pa-li-kul, is reached from Hami in three days over a pasture country beyond the pass over the Tian-shan elevated 9,000 feet; thence for 130 to 140 miles the Tian-shan is traversed by an easy cart track, leading through natural valleys, with good pasture here and there, but otherwise all desert. On leaving the hills, to Hung-miot-za or Urumtsi, 200 miles, a few towns are met with, and at intervals desert, pasture, and most fertile oases alternate. The oases are in part occupied only; the towns and villages are in ruins and rank grasses choke many of the fields.

Hung-miot-za is now the capital of Kashgaria, or the Sin-kiang or New Province, formed to include Kashgaria, Outer Kansuh, Ili, Zungaria, &c., and extending to the Russian border and Mongolia. Here the Chinese have concentrated their chief military strength, and are building a new city. Hence the cart road leads on to Ili, 400 miles. From Urumtsi the Tian-shan range was re-crossed to Toksun, a remarkable depression in Central Asia elevated about 350 feet, by an easy pass; country, generally desert; from Toksun, a hilly country is passed through, heavy for carts; road over sand and shingle, chiefly desert for 140 to 150 miles before the oasis of Karashahar is reached, the natural eastern limit of Kashgaria; to its west lies the difficult pass leading to Khur or Khorlia, 33 miles off, whence it is 340 to 350 miles to Aksu, the country between consisting of much desert, a little pasture land, with oases at intervals. A China boy from Chifu at Karashahar delivered himself of the opinion that *Sin-kiang no belong first chop piecie place*; it improves westwards, for several of the oases, Khur, Kuchar, Bai, &c., are of size, and in them grain is plentifully grown, and fruits and milk in all its varieties abound.

Aksu is an important trade centre, but a most filthy town, and here Indian merchants are first met with.

From Aksu to Kashgar the country consists of forests, deserts, and oases, some of the latter of size. Mosquitoes were in myriads between Toksun and Karashahar, and nearly killed the horses, and here the stretches of forest, some 30 to 50 miles deep, must be rushed at night, for from dawn till dusk horse-flies occupy them in millions.

At Kashgar the Russian consul makes a good show with an escort of fifty Cossacks, and his presence there is looked upon as the first step towards the annexation of Kashgaria by Russia; the Turks do not favour the Russians, but would not fight for the Chinese. They are a gone-by people and can never hope for independence; their possible future dependent position on Russia may, however, be an eventful one.

A fertile country connects Kashgar and Yarkand, and from the latter town, the chief centre of Indian trade, caravans reach Leh in a month; horses have to be trained for this hill route, which is well frequented notwithstanding its difficulties and the loss of ponies that takes place; both are remediable, and should be remedied, for to pack-animals it is a veritable passage through the vale of the Shadow of Death in its present state.

2. *Industrial and Commercial Progress in China.* *By* R. S. GUNDRY.

Premising that the wide differences in character and habits of thought between ourselves and the Chinese make it difficult to convey to an English audience an accurate impression of the situation, the paper goes on to sketch the leading features of Chinese industry and commerce in so far as they concern, and have been affected by, foreign enterprise. Beginning to move at a time when she had been defeated in a foreign war, China's first efforts were to provide herself with the warlike material which experience had shown her to be so powerful. Hence the early construction of arsenals and steamers. The beginnings of telegraphy and the acceptance in principle of railways were due also, in a measure, to warlike stress in connection with Kulja and Tongking. And mining was recognised largely as a means of providing for all this additional expenditure. But imperfection of knowledge, jealousy of foreign supervision, and a disorganised condition of finance which involves venality and harassing taxation, retard a progressive movement, to which the *literati* who constitute the mind of the nation are still as a body disinclined. The imperial finances, too, have been strained by a series of wars, rebellions, and disasters; and distrust of their officials prevents native capitalists from investing money in enterprises with which the officials persist in meddling. The great staples of tea and silk are severely menaced by the competition of India and Ceylon in the one case, and of Southern Europe in the other; and the Chinese are slow to accept improved methods of preparation which would enable them to hold their own. China tea is heavily handicapped also by taxation, in competition with its duty-free rival. Fiscal hindrances, imperfect communications, and consequent cost of transport have much to do with the slow development of trade. But the wide prevalence of domestic industry, and difficulties of exchange caused by the demonetisation of silver, tend also to check the anticipated growth of demand for our manufactures. There seems every prospect that more railways will shortly be constructed, and that machinery will be tentatively admitted for purposes of industrial manufacture. But much time, a more widespread desire for progress, and radical financial reform will be required before China is likely to rival Japan in the completeness of its transformation.

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3. *The Central Asian Railway in relation to the Commercial Rivalry of England and Russia.* *By the* Hon. G. CURZON, *M.P.*

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4. *Wind-action in Egypt.*[1] *By* W. M. FLINDERS PETRIE.

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5. *On Lake Tanganyika.*[2] *By* Captain EDWARD COODE HORE.

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6. *Portuguese Explorations in Austral Africa during the Nineteenth Century.* *By* J. BATALHA-REIS, *F.R.G.S.*

From the fifteenth century to the present time the Portuguese have not ceased to explore those parts of Africa where they settled, causing the continent to be traversed from the coast to the interior, and from the Atlantic to the Indian Ocean. Outside Portugal the greater part of the Portuguese explorations of the nineteenth century are entirely unknown. Many geographers and the public in general believe, and repeat daily, that Portugal has done nothing in Africa since the sixteenth century, and that even then her travellers explored only the African coast. As ignorance regarding this chapter of geographical history is the origin of many and great mistakes in modern questions which are linked up with politics and international right, and with which public opinion is so intensely preoccupied just now,

[1] See *Proceedings of the Royal Geographical Society*, November, 1889.
[2] Published in *Proceedings of the Royal Geographical Society*, October, 1889.

I judge it to be opportune to present an indication of the principal Portuguese explorations, at least, from the beginning of the nineteenth century, with the mention of the principal documents wherein the little-known literature of the subject may be studied.

The chief Portuguese explorations of this century commence with its earliest years. In 1802, the expedition sent out by Colonel Honorato da Costa from Angola, which traversed the whole of the continent from the basin of the Kassai to the basins of the Lualaba, Luapula, Bangweolo-Bemba, and North Loangwa, arrived at Tete in 1811.

In 1804 and 1805 Father Cannecatim published his dictionary and remarks upon the Bunda, or Angolense, language, and the narrative of his journeys in Africa.

In 1831–1832 Monteiro and Gamitto explored the region between Lakes Nyassa, Bembo-Bangweolo, and Moero and the river Zambeze.

In 1838–1848 Major Francisco J. Coimbra made his journey from Mozambique to Benguella, across Africa, and visited the lakes to the north of Kalaari.

In 1843–1847 Joaquim Rodrigues Graça went from Golungo to Bié, and thence to Lunda, almost at the eastern extremity of the basin of the Kassai.

For many years Silva Porto travelled and explored the territories between the valley of the Kwanza and that of Liambye on the Upper Zambeze. In 1852–56 his expeditions travelled from the Upper Zambeze to the Upper Luangué, and between the basins of the Zambeze and of the Congo, passed to the south of Nyassa, and crossed, diagonally, the region between the Nyassa, the Rovuma, and the sea.

In 1855–56 Montanha and Teixeira explored the territories between Inhambane, the Limpopo and the north of the Transvaal.

In 1877 expeditions of engineers were sent by the Portuguese Government to all their colonial provinces of Africa, and instituted the investigations and works which have gone on up to now, and from which the first railways in these regions had their commencement, the more perfect knowledge of many of the regions being also due thereto.

In 1877–78 Serpa Pinto crossed the continent of Africa from Benguella to Bié, and thence, by the affluents of the Kwando, to the Upper Zambeze, thence to the lakes north of Kalaari, thence through Bechuanaland to the Transvaal and Natal.

In 1877–80 Capello and Ivens went from the valley of the Cunene to the valley of the Kwanza, and thence to that of the Kwango, which they investigated nearly as far as lat. 6° S.

In 1883 Antonio Cardoso visited the districts which lie between the river Save and the upper valleys of the river Buzi.

From 1880 Paiva d'Andrade has been exploring the lands which lie between the Zambeze and the valleys of the Save and Buzi and Limpopo.

In 1884–1885 Capello and Ivens travelled right across Africa, from Mossamedes to the rivers Cunene, Cubango, Liambye, Lualaba, Luapula, Lake Bemba, and thence to the Zambeze, from near the mouth of the Kafue to the sea.

In 1885–1886 Augusto Cardoso traversed from Ibo to the Nyassa, and thence by the Shiré to the Zambeze.

In 1884–1888 Henrique de Carvalho and Sisenando Marques investigated the territories between the Kwanza and the Kassai in the districts of Lunda, Carvalho going as far as the river Kshidish, an affluent of the Muansangoma, near the 24th degree of E. long.

These are the better-known travels, but the Portuguese have undertaken very many less extensive but more minute explorations than these, which are almost entirely unrecognised, and cannot be mentioned in a brief abstract; they have thus covered with a work of uninterrupted investigation, from the sixteenth century up to the present time, almost all the more important regions of Africa which can be found between a line drawn from the mouth of the Congo to that of the Rovuma, and from that of the Cunene to the south of that of the Limpopo.

Many explorations, exclusively scientific, more limited, and more delayed in

their results, have been and still continue to be carried on. It was under the Portuguese Government that Welwitsch made his investigations and botanical collections in Angola (1853–60), which are amongst the principal bases of all that has been published on the Tropical African flora. In 1864–5 Pinheiro Baiaõ collected important zoological specimens in the districts between the Lucala and the Bengo in Eastern Africa, as did the two Missionaries, Father Antunes in Huilla, and Father Barrozo in the Congo district. From 1864 José d'Anchietta has resided in the interior of Africa, and thence has sent the notable investigations and magnificent collections, for the most part zoological, which so enrich the Natural History Museum of Lisbon (Eschola Polytechnica), and which, in part, have been studied by Professors Bocage (reptiles, birds, mammalia), J. A. de Sousa (birds), Felix Capello. Guimarens, Osorio (fishes and crustacea), Mattoso dos Santos (myriapoda), M. Paulino de Oliveira, A. Girard (insects), Count de Ficalho (flora), &c., not to mention other than the principal Portuguese *savants*.

By the said Anchietta are some recent geological researches upon the Angola formations; and upon his collections, those of L. Malheiro (1883), and those of other travellers, the investigations of Delgado, Choffat, and other geologists of the Lisbon Geological Commission have been founded.

The work of the Lisbon Geographical Society, and its action in the exploration and investigation of Africa, and the researches of its secretary, Mr. Luciano Cordeiro, deserve important mention.

The principal and less-known sources whence to study recent Portuguese explorations are:—'Boletim e annaes do Conselho Ultramarino; Annaes maritimos e coloniaes'; 'Annaes da Marinha Portugueza'; 'Boletins officiaes da Provincia de Angola'; 'Boletins officiaes da Provincia de Mozambique'; 'Boletins [and other publications] da Sociedade de Geographia de Lisboa': 'Jornal das Sciencias Mathematicas e Naturaes da Academia das Sciencias de Lisboa'; Boletim [and other publications] da Commissão dos Trabalhos geologicos de Portugal'; 'Memorias estatisticas das Colonias Portuguezas,' by Botelho, Lopes Lima, Bordalo; 'As Colonias Portuguezas,' &c.

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7. *Nyassaland and its Commercial Possibilities.* *By* Captain Lugard.

As a sequel to the cartography of the African continent, comes the wish to know something of its peoples, climates, products, and resources. What we now want to know is whether Africa can supply the wants of European civilisation, and take in return the products of our manufactures. Above all, whether it is a suitable field for emigration for Europeans or others. Nyassaland may be defined as the country bounded on the north by Lake Tanganyika and Congo Free State, on the west by Bangweolo, Moero, and Congo Free State, south by Zambesi, east by Shirwa, Nyassa, and Leopold. This country has recently come into public notice—(α) As a centre of the slave trade; (β) of mission work and philanthropic trading efforts; (γ) of recent fighting of a special character. These points have gained for it a notoriety which may be said to have a practical commercial value.

a. Missions afford a large carrying trade for a trading company. They develop the wants of European goods among the natives, such as calico, soap, beads, brass wire, &c. So also in a less degree do the Arab settlements, and with these too trade should be developed by the offering of better prices for ivory, &c.

In return for the articles of European manufacture we should get:

1. From native chiefs.—The entrée into their country, with a view to exploiting the minerals. In payment ivory and other local products.

2. From the Arabs.—Toleration, they being numerically superior. Ivory.

3. From the people.—Labour and porterage, and minor products.

The missions also afford a strong moral support to a company, and exert an influence with government, and on public opinion, which will ensure the recognition of the claims of a company.

β. The anti-slavery element also exercises a moral weight.

The products of the country may be divided into primary, which will pay for

their own export; and secondary, which will bring in some return while the others are being developed, but are mainly useful for local consumption to save import of European stores, &c.

Primary products are—(1) minerals, in which we have good grounds to believe that the country is very rich. This is *the* desideratum.

2. Ivory, which is, however, a decreasing product. The elephant is being rapidly exterminated. Plea for its preservation and domestication. Desideratum is a means of transport; possibility of taming the zebra or breeding zebra mules.

3. Coffee indigenous and already widely cultivated at Blantyre.

4. Tea, cloves, chinchona-bark, rubber, indigenous drugs.

Secondary products can at first be exported in the empty returning steamers, but are mainly useful for local use.

1. Misanguti tree furnishes oil, and dye, and timber, and from it can be made candles, soap, and oilcake for cattle.

2. Hides, which should be roughly prepared on the spot for exportation. (Materials for this rough process are available on the spot).

3. Oil seeds of various kinds.

Other cultivable products are wheat, linseed, flax, indigo, cotton and opium; the latter and sugar have already succeeded.

4. Fibres of plantain, tree-bark, and hemp.

5. Drugs, such as strophantlos, and others yet unknown.

6. Valuable plants, orchids, herbs, ferns, &c.

7. Timber, indigenous as ebony, and imported. Plea for importation of Indian useful trees, and arguments for supposing they would do well.

Nyassaland as a field for immigration:

a. For Europeans.—The high lands have proved healthy, but a means of rapid transit through the deadly coast area is a necessity.

β. For Indians.—Even the coast area has already been peopled with them.

1. They must be of a sturdy fighting class who can protect themselves.

2. They would supply the wants, and form the recruiting basis for a nucleus of a fighting force.

3. Above all they would introduce the Indian methods of agriculture, and so aid in the development of the African tribes.

The scheme appears feasible, and we have reason to think would be accepted by the Punjab races.

Nyassaland has great claims to be opened up by the British, and the time has now come for our Government to decide whether they will accept the position or leave it.

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8. *On the Zambezi Delta. By* B. DANIEL J. RANKIN.

The author gave a general description of the Zambezi Delta from the conflux of the Shiré River to the sea. He spoke of the condition of the people; indicated the routes used by trade from the interior to the sea, showing how the primitive and inefficient means of communication have tended against the development of trade. He then referred specially to the Inhamissengo, or Slongoni outlet, and the Chindé river—its character and suitability for traffic. He spoke of the physical characteristics of the Chindé mouth; the advantages of using this as the trade outlet, both from a political and commercial point of view, showing how, by using this new outlet for trade, a commercial enterprise formed on the lines of the Niger or Imperial East Africa Company would have every prospect of success.

SATURDAY, SEPTEMBER 14.

The Section did not meet.

MONDAY, SEPTEMBER 16.

The following Papers were read:—

1. *The Present and Future of Queensland.* *By* Carl Lumholtz, *M.A.*

The author pointed out that Queensland, the youngest of the Australian colonies, is three times as large as France, and nearly six times as large as the United Kingdom, yet contains a population of less than 400,000. The progress of settlement from the year 1859, when Queensland, separating from the mother colony of New South Wales, became independent, was mentioned, and the question raised whether in the future there will not be a northern colony devoted to tropical agriculture, with coolie labour legalised and recognised. It was shown that the western interior, which used to be considered as a howling wilderness, has in comparatively recent times been proved to be prairie-land abounding in the richest natural herbage growing out of deep chocolate-coloured or black virgin soil. The capabilities of the colony for tropical, semi-tropical, and European products in agriculture were mentioned, and the necessity of an artificial system of irrigation enjoined. The author's residence among the uncivilised aborigines of the Herbert River in North-Eastern Queensland was described, with particulars of their modes of life. He found them to be undoubted cannibals, and shares with other travellers the belief that the Australian native, like the Tasmanian, soon will vanish before the advance of civilisation. The Australian aborigine may still be said to be in the palæolithic age.

In the whole history of man a more sudden revolution is not known than that which happened in Australia during this century; and Queensland, with its semi-tropical and tropical riches, with its ability to produce sugar of high quality and in any quantity, with its extraordinary yield of precious minerals, such as that which makes Mount Morgan gold mine one of the wonders of the world, with its seaboard of 2,500 miles, with its healthy climate, with its free institutions, is nobly fulfilling the aspirations which have made the Anglo-Saxon the most successful colonists of all the ages.

2. *Notes on the recent Development, Exploration, and Commercial Geography of British North Borneo.* *By* Alexander Cook.

This paper traced in detail the development of North Borneo under the action of the British company under whose care it is placed. The author described the various natural and introduced products, and adduced data to prove how rapidly the commerce of the region has developed.

3. *Recent Explorations in Peru and Bolivia.* *By* H. Guillaume.

This paper described the efforts which have been made by Peruvian and Bolivian explorers and traders to open up the rivers and the dense forest country lying between them. Colonel Labre since 1872 has been endeavouring to open communication from the Purus to the Beni. He explored the river Itury and its affluents several times, as to the character and navigability of which he has contributed much new information. Padre Nicolas Armentia explored the Madre de Dios in 1885, and resided for some time in the country of the Araonas Indians. From its mouth for 280 miles the river receives no important tributary; the Padre believes it has a navigable course of 400 miles for steamers. Mr. Guillaume described in detail the gold-bearing region at the source of the Madre de Dios. He then referred in detail to the explorations of Senor Carlos Fry on the Ucayli and its tributary the Urubamba.

4. *Geographical Co-ordinates in the Valley of the Upper Nile.*[1] *By* E. G. Ravenstein, *F.R.G.S.*

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5. *The Resources of Siberia, and the Practicability of the Northern Sea Route.* *By* R. Sulivan.

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6. *Greenland.* *By* Dr. Fridtjof Nansen.

TUESDAY, SEPTEMBER 17.

The following Report and Papers were read:—

1. *Report of the Committee for investigating the Geography and Geology of the Atlas Ranges in the Empire of Morocco.*—See Reports, p. 165.

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2. *On the Exploration of the Louisiade and d'Entrecasteaux Islands.* *By* Basil H. Thomson.

The paper described the exploration of the following Islands:—Sudest, Rossel, Joarmet, St. Aignan, East Island, Normanby, Goulvain, Ferguson, Goodenough, alluding to the geological formation, the flora and fauna, and the habits, appearance, and language of the natives with whom the expedition came in contact. An account was given of the habits of the 'Manucodia' and 'Paradisea Decora' peculiar to the d'Entrecasteaux Islands, and the curious series of hot springs and geysers in Seymour Bay were described.

It concluded with a short account of the arrest of the Ancell murderers in Chad's Bay, with whom the expedition came into hostile collision.

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3. *On the Bahrein Islands in the Persian Gulf.* *By* J. Theodore Bent.[2]

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4. *On some remarkable Monuments in the neighbourhood of Tiaret in Algeria.* *By* Colonel Sir Lambert Playfair, *K.C.M.G.*

These monuments are only now rendered accessible by the extension of the railway to that place. The country through which it passes is rich and fertile, but hardly cultivated, owing to the unthrifty habits of the Arab, who will always rather plough round a thistle than root it up, and who requires a greater extent of land to maintain him in misery than a European family would to live in comfort and prosperity. The remains of the past show what the future may become; the commune of Tiaret alone contains about one hundred places corresponding to Roman towns, villages, or agricultural establishments.

The interesting monuments called *Djedars* are in two groups between Tiaret and Frenda. Their general form is that of a podium, about 30 or 40 metres square, surmounted by a pyramid. They contain intricate passages and sepulchral chambers. In front of each is an isolated platform, probably designed for some religious ceremony, and each was surrounded by a wall, forming a sort of sacred enclosure, probably planted with trees and shrubs. They are situated on the tops of isolated peaks, and are visible from a considerable distance on every side.

[1] Printed in the *Proceedings of the Royal Geographical Society*, November, 1889.
[2] See *Proceedings of the Royal Geographical Society*, January, 1890.

These were evidently the sepulchres of a native dynasty, Catholic in religion, vassals successively of the Romans and Byzantines, which were swept away at the time of the Arab invasion in the seventh century.

He also described a curious megalithic city called Mechera Sfa, on the banks of the Mina, probably intended to afford a place of refuge to the inhabitants of the neighbouring country in time of danger. The summit of a hill is strongly fortified, the enclosure full of rude stone dwellings, and the bottom of the valley as well as the sides and top of the opposite hill covered with tombs, generally formed of immense monoliths, and sometimes surmounted by tumuli of earth.

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5. *On Two Models illustrating the Action of the Winds in relation to Ocean Currents.* *By* A. W. CLAYDEN, *M.A.*

The principle upon which these models are constructed is to make a map in which the oceans are represented by the surface of water, over which some lycopodium powder is scattered. A number of tubes are connected with a reservoir into which air can be forced, and they are so arranged that the jets which issue from them set up movements of the air over the water surface, similar to those of the prevalent winds. The result is to create systems of water currents resembling those of the region represented.

One model shows the currents of the Atlantic, the other those of the Indian Ocean. This latter has an additional valve attached by which the winds can be caused to blow as they do during either the North-East or during the South-West monsoon, and the consequent change of the currents can be seen.

They are designed with a purely educational object in view, being part of a scheme for treating the study of physical geography in an experimental manner.

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6. *The North-West Territories of Canada.* *By* J. G. COLMER, *C.M.G.*

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7. *The South Coast of West Java.* *By* H. B. GUPPY, *M.B., F.R.G.S.*

In this paper the author dealt with a part of Java which has not been much described. It is one of the least familiar portions of this large island, a circumstance due partly to its paucity of anchorages and to the difficulty in landing; partly to its having been allowed to become in some places a kind of menagerie; and partly, also, to the fact that it lies remote from the chief seats of government. Now that the Netherlands Indian Government are rapidly carrying out their systematic survey of the Preanger Residency, it will not be long before the south coast of West Java will be much better known than it is at present: and the recent extension of the central railway to Garoet and Tjirajap will do much to effect this end. The author's tracks over West Java would make a chequered pattern on a map; but he thought it better not to refer to localities already well known—localities which are now yearly visited by hundreds of visitors. Taking the central railway as his base, he performed nearly all the distance on foot, walking about 560 miles in all. In the paper he endeavoured to give a general idea of this south coast alone. The huge volcanic cones were landmarks to him, and nothing more; they had been well described by Junker and others, so he resisted the temptation of climbing them, and reserved his main efforts for the examination of the little described and remote south coasts of the Preanger and Bantam Residencies.

The object he had in view was to ascertain what physical evidence there was for the belief that the west end of Java was originally united with Sumatra. In this paper the author showed that all the evidence on the Java side of the Sunda Strait points to the opposite conclusion. Zoological evidence cannot be held sufficient to establish the previous connection between two islands without the physical evidence of such a change. The problem, as usually stated, seems to begin at the wrong end of the matter. Given the present distribution of plants and animals, it

is then attempted to explain the previous arrangement of the land, and this is done too often without appealing to the physical evidence at all. In tracing geographical changes in the past, it would seem more reasonable to adopt an opposite method; but in the great majority of cases affecting the distribution of animals, it would be wiser in the first place to assume the *status quo*, and fall back when that fails on the physical evidence of the presumed changes.

Section F.—ECONOMIC SCIENCE AND STATISTICS.

President of the Section—Professor F. Y. Edgeworth, M.A., F.S.S.

THURSDAY, SEPTEMBER 12.

The President delivered the following Address:—

Points at which Mathematical reasoning is applicable to Political Economy.

A.—Perfect Competition—
1. Simplest type of market.
2. Complex system of markets; simplified by certain abstractions.
3. The more concrete problem of an Exchange and Distribution.

B.—Monopoly—
1. Transactions between a single monopolist and a competing public.
2. Transactions between two monopolists or combinations.

The use of these applications of Mathematics to Political Economy illustrated by comparison with—
1. Applied mathematics generally.
2. The mathematical theory of Statistics.

Notes.

At the meeting of the British Association which was held at Cambridge about a quarter of a century ago, Jevons submitted to this section a 'general mathematical theory of political economy,' which, as he himself records, was 'received without a word of interest or belief.' I propose to consider the justice of the unfavourable verdict which our predecessors appear to have passed on the mathematical method introduced by Jevons.

There is some difficulty in discussing so abstruse a subject in this place. It is as if one should discourse on the advantages of classical education on an occasion on which it might seem pedantic to cite the learned languages. I shall evade this difficulty by addressing to students some appended notes,[1] which, like the boy of the proverb, are to be seen, not heard.

The cardinal article of Jevons's theory is that the value in exchange of a commodity measures, or corresponds to, the utility of the least useful portion of that commodity. What a person pays per month or year for a sack or ton of coal is not what he would be willing to give for the same rather than be without fuel altogether. Rather the price is proportioned to the advantage which the consumer expects from the portion which he could best dispense with—to the 'final utility,' in Jevons's happy phrase.

I shall not be expected here to dwell on a subject which has been elucidated in treatises of world-wide reputation, such as those of Professors Marshall, Sidgwick, Walker, and I would add Professor Nicholson's article on Value in the 'Encyclopædia Britannica.' Those writers seem to present what I may call the economical kernel of Jevons's theory divested of the mathematical shell in which it was originally enclosed; whereas my object is to consider the use of that shell: whether it is to be regarded as a protection or an encumbrance.

I may begin by removing an objection which the mere statement of the question raises. The idea of reducing human actions to mathematical rule may present itself to common sense as absurd. One is reminded of Swift's 'Laputa,' where

[1] The appended notes are referred to by letters of the alphabet, thus: (*a*).

the beef was cut into rhomboids and the pudding into a cycloid, and the tailor constructed a very ill-fitting suit of clothes by means of rule and compasses. It should be understood, however, that the new method of economical reasoning does not claim more precision than what has long been conceded to another department of science applied to human affairs, namely, Statistics. It is now a commonplace that actions such as suicide or marriage, springing from the most capricious motives, and in respect of which the conduct of individuals most defies prediction, may yet, when taken in the aggregate, be regarded as constant and uniform. The advantage of what has been called the law of large numbers may equally be enjoyed by a theory which deals with markets and combinations.

But, indeed, even the limited degree of arithmetical precision which is proper to statistical generalisations need not be claimed by our mathematical method rightly understood. It is concerned with quantity, indeed, but not necessarily with number. It is not so much a political arithmetic as a sort of economical algebra, in which the problem is not to find x and y in terms of given quantities, but rather to discover loose quantitative relations of the form: x is greater or less than y; and increases or decreases with the increase of z.

Such is the character of what may be called perhaps the leading proposition in this calculus, namely, the mathematical theory of Supply and Demand. The use of a curve introduced by Cournot to represent the amount of a commodity offered, or demanded, at any particular price, supplemented by Jevons's theory of final utility (*a*), does not indeed determine what price will rule in any market. But it assists us in conjecturing the direction and general character of the effect which changes in the condition or requirements of the parties will produce. For example, in the case of international trade the various effects of a tax or other impediment, which most students find it so difficult to trace in Mill's laborious chapters, are visible almost at a glance by the aid of the mathematical instrument (*b*). It takes Professor Sidgwick a good many words to convey by way of a particular instance that it is possible for a nation by a judiciously regulated tariff to benefit itself at the expense of the foreigner. The truth in its generality is more clearly contemplated by the aid of diagrams such as those employed by the eminent mathematical economists Messrs. Auspitz and Lieben (*c*).

There seems to be a natural affinity between the phenomena of Supply and Demand and some of the fundamental conceptions of Mathematics, such as the relation between function and variable,[1] between the ordinate of a curve and the corresponding abscissa,[2] and the first principles of the Differential Calculus, especially in its application to the determination of *maxima* and *minima*. The principle of Equilibrium is almost as dominant in what Jevons called the Mechanics of Utility as in Natural Philosophy itself (*d*). In so many instances does mathematical science supply to Political Economy what Whewell would have called 'appropriate and clear' conceptions. Their use might, perhaps, be illustrated by comparing—however fancifully, and *si parva licet componere magnis*—the advance in Economics which Jevons initiated or continued to the advance in Mathematics which the higher method invented by Sir William Rowan Hamilton appears to have effected. Algebra and Geometry are to ordinary language in Political Economy somewhat as quaternions are to ordinary algebraic geometry in mathematical physics; if we accept the view of the latter relation which has been given by a very competent judge, Clerk Maxwell. 'I am convinced,' he says, 'that the introduction of the ideas as distinguished from the operations and methods of quaternions will be of great use in the study of all parts of our subject, and especially . . . where we have to deal with a number of physical quantities, the relations of which to each other can be expressed far more simply

[1] The treating as constant what is variable—e.g., *supply*, *margin*, *wages-fund*, is the source of most of the fallacies in Political Economy.

[2] For instance, the two meanings of increased demand—which Mr. Sidgwick has contrasted as the *rise* and the extension of demand—are most easily and with least liability to logomachy distinguished as the variation of an ordinate (1) due to the displacement of the curve, the abscissa not varying, or (2) corresponding to an increment of the abscissa, the curve being undisturbed.

by a few expressions of Hamilton's than by the ordinary equations.'[1] This is the spirit in which the economist should employ Mathematics—'the ideas as distinguished from the operations and methods.'

In considering the above-given, and indeed any concrete instances, it is hardly possible to keep to what may be called the simplest type of Supply and Demand, the ideal market in which we contemplate only two groups of competitors and only two articles of exchange: say, gold for corn, or any other *quid pro quo*. In general, and especially when considering what rates of exchange tend to rule in an average of transactions, it is proper to take into account that the dealings in one market will affect those in another. If the *entrepreneur* has less to pay for machinery, *cæteris paribus*, he will be able to offer more on the labour market. Thus we obtain the idea of a system of markets mutually dependent. In a general view of this correlation it is not necessary to distinguish whether the state of one part is connected as cause or effect with the other parts of the system. As Professor Marshall says:[2] 'Just as the motion of every body in the solar system affects and is affected by the motion of every other, so it is with the elements of the problem of political economy' (*e*).

This conception of mutually dependent positions is one in which minds disciplined in mathematical physics seem peculiarly apt to acquiesce. In other quarters there may be observed a restless anxiety to determine which of the variables in a system of markets is to be regarded as determining or regulating the others. In one of the principal Economic journals there has lately been a pretty stiff controversy on the question which of the parties in the distribution of the national produce may be regarded as 'residual claimants upon the product of industry';[3] whether it is the working class which occupies this preferential position, or if the 'real keystone of the arch' is interest. Such questions certainly admit of a meaning, and probably of an answer. But they will probably appear of secondary importance to those who accept, as the first approximation to a correct view of the subject, the principle of mutual dependence—what may be called the Copernican theory of distribution, in which one variable is not more determined by another than the other is by that one (*f*).

Among the factors of this economic equilibrium I have not as yet explicitly included cost of production. Rather, the system of markets which so far I have had in view is that which would arise if all the articles of exchange were periodically rained down like manna upon the several proprietors, and each individual sought to maximise his advantage according to the law of final utility. But now we must observe that self-interest does not operate only in this fashion. We must take account of efforts and sacrifices.

Here again the language of symbol and diagram is better suited than the popular terminology to express the general idea that all things are in flux, and that the fluxions are inter-dependent. In Professor Marshall's words, 'as a rule, the Cost of production of a thing is not fixed; the amount produced and its normal value are to be regarded as determined simultaneously under the action of Economic Laws. It, then, is incorrect to say, as Ricardo did, that Cost of production alone determines value; but it is no less incorrect to make utility alone, as others have done, the basis of value.'[4] Among those who may have gone astray in the latter sense, who, in their recoil from Scylla, are at least sailing dangerously near Charybdis, may be placed the important Austrian school who have rediscovered and restated the theory of final utility without the aid of mathematical expression. To amplify a figure suggested by one of them,[5] let us figure the hard conditions of industrial life

[1] Clerk Maxwell, *Electricity and Magnetism*, Art. 10. He says in the context, 'As the methods of Descartes are still the most familiar to students of science, and as they are really the most useful for purposes of calculation, we shall express all our results in the Cartesian form.' Compare Professor Marshall's dictum with respect to the use of the vulgar tongue in economic reasonings, cited below, p. 9.

[2] In a remarkable review of Jevons's Theory in the *Academy* of April 1, 1872.

[3] *Quarterly Journal of Economics*, 1887, p. 287; 1888, p. 9.

[4] *Economics of Industry*, p. 148.

[5] Cf. Professor Böhm Bawerk: 'Es kann ein Erzieher einem Knaben, um ihn gegen Wehleidigkeit abzuhärten, für die tapfere, freiwillige Erduldung von Schmerzen

by the austerity of a schoolmaster who, in order to cultivate patience and fortitude in his scholars, should distribute among them certain rewards—it might be toys and sweets—in return for certain amounts of fatigue and pain endured. Thus the cost of procuring a marble might be writing out twenty lines, the cost of a top standing half an hour in the stocks. Supposing exchange to be set up among the members of the youthful population, free competition being assumed, there would theoretically arise an equilibrium of trade in which the value of each article would correspond to its final utility. That is, if a top exchanged for ten marbles, it might be expected that each boy would prize the last top about as highly as the last decade of marbles which he thought fit to purchase. So far final utility might be regarded as the regulating principle.

But it is equally true that the final *dis*-utilities of the exchanged articles will be equal. If a top is worth ten marbles, we are entitled to expect such an adjustment of trade that each and every boy would as soon stand in the stocks half an hour as write out two hundred lines—the cost of ten marbles at twenty lines per marble.

To be sure final utility may be conceived as operating by itself without reference to cost of production, as we tacitly assumed in our first paragraphs. Whereas the converse conception of a traffic in discommodities [1] has less place in real life.

But it is not worth while weighing the two principles against each other, *in vacuo*, so to speak, and abstracting the real circumstances by which each is differently modified. As these are introduced the balance will oscillate now in favour of one side, now of the other; perhaps leaving it ultimately uncertain whether Cost of Production or Final Utility is the more helpful in the explanation of economic phenomena.

For instance, in our allegory let us introduce the supposition that there is only one variety of cost—say the common labour of writing out verses. If now the authorities fix twenty lines as the cost of a marble, and two hundred as the cost of a top, it is predictable that a top will be worth ten marbles. It is equally true indeed, now as before, that the final utility of a top will be equal to the final utility of ten marbles. But the latter proposition, though equally true, is not equally useful. For it does not afford the simple and exact method of prediction which is obtained by the Ricardian view upon the supposition made. But then the supposition that there is only one variety of sacrifice is not always appropriate. And even if it were appropriate, it might not be helpful when we introduce the condition that the cost of procuring each article is not fixed definitely, but varies increasingly or decreasingly with the amount procured. Thus the cost of the first marble given out might be twenty lines; of the next marble, twenty-one lines; with an equally varying scale for tops. Upon this supposition the two propositions that value corresponds to final utility and also final disutility might be equally true, but equally useless for the purpose of prediction.

Again, it may be that a man is freer to vary the extent of his expenditure than the duration of his work (*g*). The final disutility experienced by the Secretary of this Association during its meetings must be fearful. For it is not open to him to terminate at pleasure his day's work, as if he were employed by the piece. He would not, however, have accepted the office unless the advantages, less by all the

ein sehnlich begehrtes Spielzeug in Aussicht stellen. So untergeordnet das Vorkommen solcher Fälle auch sein mag, so wichtig ist es für die Theorie festzustellen, dass Arbeit und Arbeitsplage doch nicht der einzige Umstand ist, auf den sich . . . . die Wertschätzung gründen kann.'—*Konrad's Jahrbuch*, 1886, p. 43.

[1] Suppose our allegorical schoolmaster should discontinue the system of rewards and prefer to cultivate diligence by requiring each boy from time to time to bring up a certain number of lines, written out—whether by himself or another would not be scrutinised—or to be responsible for the cleaning of a window, after the manner of Mr. Squeers's practical method. In the traffic of discommodities which would be set up on this supposition the (negative) value of each article of exchange would be measured solely by its disutility. However, it must be admitted, I think, that this latter hypothesis is rather more absurd than the former abstraction—with reference to real life at least; for, as it happens, the traffic in impositions more nearly resembles what is said to occur in actual schools.

trouble, were at least as great as in any other position open to him. Now this equation of the Net Advantages in different occupations is—co-ordinately and (in a mathematical sense) *simultaneously* with the equation of final utility for different kinds of expenditure—a condition of normal economic equilibrium (h). Yet again, the free play of this tendency is impeded by the existence of 'non-competing groups.'

I cannot be expected here to enumerate all the conditions of economic equilibrium. For a complete exposition of the complexities, at which I have thought it necessary to glance, I must refer to the second book of Professor Sidgwick's 'Political Economy.' It will be evident to his readers[1] that what may be called the general economic problem of several trading bodies distributing and exchanging *inter se* under the influence of self-interest and in a régime of competition is much more hopelessly difficult than the as yet imperfectly solved dynamical problem of several material bodies acting on each other *in vacuo*. When Gossen, the predecessor of Jevons as exponent of the law of final utility, compares that principle to the law of gravitation, and the character of our science to that of astronomy, he betrays a parental partiality. A truer, though still too flattering, comparison would be afforded by some very immature and imperfect specimens of physics, say the theory of fluid motion applied to the problems of house ventilation.

There is a certain resemblance between the uniformity of pressure to which the jostling particles of a gas tend and the unity of price which is apt to result from the play of competition. As the architect is guided by studying the laws according to which air flows, so it will help the builder of economic theory to have mastered the principle of movement towards equilibrium. But even in the material constructions practice is apt to lag far behind theory, as every reader in the British Museum knows. Much less are we able to predict what currents will flow between the different compartments of the industrial system. We know so imperfectly the coefficient of fluid friction, and the other conditions of the general problem: what compartments may be regarded as completely isolated and hermetically sealed, which partitions are porous and permeable.

Indeed there has been noticed one mode of competition, which it does not seem easy or helpful to represent by physical analogies—the transference from one occupation to another, the equation of net advantages or total utilities in different employments; industrial as distinguished by Cairnes from commercial competition. The latter operation appears to me to admit much better of mathematical expression than the former, which is not so well represented by the equilibrium of a physical system.[2] Accordingly the equation of net advantages has been judiciously omitted by Jevons in his formulation of the cost of production. And the Helvetian Jevons, as we may call Professor Walras, appears to have altogether made abstraction of the cost of production considered as importing sacrifice and effort.

[1] There occurs to me only one point at which the use of mathematical illustrations more complicated than those which I have referred to in my first two headings would conduce to the apprehension of Mr. Sidgwick's theorems. I allude to his repeated statement that, not only in International trade, as Mill pointed out, but also in trade in general, there may be several rates of exchange at which the supply just takes off the demand. This statement, taken without reservation, goes the length of destroying the prestige which is now attached to competition. Professor Marshall in an important passage recommends arbitrators and combinations to imitate the method of a celebrated engineer, who, in order to make a breakwater, first ascertained the slope at which a bank of stones would naturally be arranged under the action of the waves, and then let down stones so as to form such a slope (*Economics of Industry*, p. 215). Now, if gravitation acted sometimes vertically and sometimes at an angle of 45° if the forces of competition tended to two distinct positions of equilibrium, the construction of the economic breakwater would become arbitrary. It is important, therefore, to show the limits of Professor Sidgwick's theory. *See* the appended note j.

[2] Commercial competition might be likened to a system of lakes flowing into each other; industrial competition to a system of vessels so communicating by means of valves, that when the level in one exceeded that of another to a certain extent, then *per saltum* a considerable portion of the contents of that one (a finite difference as compared with the differentials of the open system) is discharged into the other.

Professor Walras, illustrating the operation of a simple market, supposes each dealer, before going to market, to write down his scale of requirements—how much he would be willing to buy or to sell at each price. From these data it would be easy to calculate beforehand the rate of exchange which would prevail in the market formed by those individuals. But, when we advance from the simplest type of market to the complexities introduced by division of labour, it is seen to be no longer a straightforward problem in algebra or geometry, given the natures of all the parties, to find the terms to which they will come. Here, even if we imagine ourselves in possession of numerical data for the motives acting on each individual, we could hardly conceive it possible to deduce *à priori* the position of equilibrium towards which a system so complicated tends.

Accordingly it may be doubted whether the direct use of mathematical formulæ extends into the region of concrete phenomena much below the height of abstraction to which Jevons has confined himself. However, the formulation of more complicated problems has still a negative use, as teaching the Socratic lesson that no exact science is attainable. As Dupuit, one of the greatest of Jevons's mathematical predecessors, points out, 'Quand on ne peut savoir une chose, c'est déjà beaucoup que de savoir qu'on ne sait rien.'[1] If, he says, the early theorists, instead of formulating the balance of trade, had confined themselves to declaring the question above their powers, they would probably have done a greater service than the successors who refuted them. So Cournot, referring to his own mathematical treatment of economics, 'Aussi nos modestes prétensions étaient-elles non d'accroître de beaucoup le domaine de la science proprement dite, mais plutôt de montrer (ce qui a bien aussi son utilité) tout ce que nous manque pour donner la solution vraiment scientifique de questions que la polémique quotidienne tranche hardiment.'[2] Similarly Jevons says,[3] 'One advantage of the theory of economics, carefully studied, will be to make us very careful in our conclusions when the matter is not of the simplest possible nature.'

In the vineyard of science to perform the part of a pruning-hook is an honourable function; and a very necessary one in this age of luxuriant speculation, when novel theories teem in so many new Economic journals. I give in the appended notes an example of this corrective process applied to a theory of great worth and authority, and concerning the most vital interests, such as the relations of employer and employed, and the Socialist attack on Capital (*i*). In directing this weapon of criticism against Professor Walker, I act upon the Miltonic rule for selecting an adversary:

> 'Best with the best, more glory will be won,
> Or less be lost.'

In the preceding remarks I have had in view, as presumably most favourable to computation, the case of bargains in which there is competition on both sides. It is now to be added that the mathematical method is nearly as applicable to a régime of monopoly. Here Cournot, rather than Jevons, is our guide. Cournot's masterly analysis of the dealings between a monopolist seller and a number of buyers competing against each other has been copied out of mathematics into the vulgar tongue by many well-known writers, and need not here be repeated (*k*).

It is in this department perhaps that we can best answer Cairnes's challenge to Jevons to produce any proposition discovered by the mathematical method which is not discoverable by ordinary reasoning. Not, indeed, that the economist is bound to answer that challenge; any more than, in order to prove the advantages of international trade, he is concerned to deny that claret may be produced in Scotland.

The following proposition is a particular case of a more general theorem given by Cournot. Let there be a railway and a line of steamers, each forming part of a certain through journey, and separately useless; the fares will be lower when both means of transport belong to a single company than where there is less monopoly,

[1] *Annales des Ponts et Chaussées*, 1844, p. 372.
[2] *Revue Sommaire.*
[3] *Theory of Political Economy*, p. 157, second edition.

the two services being in the hands of two companies, each seeking its own gain independently of the other.

The *rationale* of this somewhat paradoxical proposition is not easily discerned without the aid of symbols. Cournot, in a popular[1] redaction of the theories which he first conceived in a mathematical form, suggests, as a generally intelligible explanation, that it is better to be at the mercy of a single master than of several petty tyrants. But this seems to be a commonplace of the sort which, in the absence of rigid reasoning, has so often deceived the amateur economist. Might it not be applied to the case of monopoly in general?

It would be hard to say how much this remarkable proposition may add to the arguments in favour of the Government monopolising railways. Nor would I undertake to estimate the practical significance of Cournot's numerous mathematical theorems on the taxation of monopolists. We might perhaps compare the function of the sovereign science with respect to the theory of monopolies to the duty of Government as to their management—to exercise a general supervision without attempting to control details.

We have in the last few paragraphs been supposing monopoly on one side of the market, on the other side a public competing with each other. Let us now consider the bargain between two monopolists, whether individuals, or rather corporate trading-bodies, combinations in the most general sense of the term. The mathematical analysis of this case brings very clearly into view the important property, which is not very prominent in writings of the pre-Jevonian era, that the bargain between two self-interested co-contractors is not determinate in the same sense as in a régime of perfect competition.

No doubt, if we take a very simple case—such as that imagined by De Quincey, of a bargain between the owner of a musical-box and a colonist already on his way to a distant region where no luxuries can be purchased—it is easy to see that the bargain may settle down at any point between certain limits. But where both the amount of commodity to be sold and money to be paid are variable, as in the momentous case of the bargain between a combination of employers on the one hand and employees on the other, it is a less familiar truth that the terms of the contract are in general to some extent indeterminate. For instance, the bargain may be either all in the interest of the one party, say long hours and small pay, or on the other hand high wages with much leisure.

The significance of this proposition has been missed by many of those who have treated the subject without the aid of the appropriate apparatus. Some fail to see that there is any peculiarity in the bargain between isolated units. Another discerns the indeterminateness of the bargain only in the special case in which the article exchanged is a large indivisible object, like a house. Another limits the difficulty to the case of a single negotiation as distinguished from a contract which, as in the actual labour market, may be modified from time to time. Another tells us that in such a bargain the most anxious party gains least.

All these phrases seem to obscure the cardinal distinction that perfect competition tends to a determinate settlement, whereas in a régime of combination a principle of adjustment is still to seek. What is that principle?

At a former meeting of the British Association, on the occasion of a discussion on sliding scales, I stated the difficulty which there might be, in the absence of competition, in defining fair wages and reasonable terms, and I asked the eminent Professor who introduced the subject in what direction one should look for a solution of this difficulty. His reply imported, as I understood, that no other general rule can be given but this: to obtain a full knowledge of, and bring a candid judgment to bear on, all the circumstances relevant to each case. To which I would add that one circumstance relevant to this whole class of cases is just the fact that there is in the abstract such a marked difference between combination and competition.

Possibly the dry light of abstract science may enable us to see a little further into this difficulty. Analysis strongly suggests that the right solution is what

[1] *Revue Sommaire.*

may be called the utilitarian arrangement, that which is productive of the greatest sum total of advantage for all concerned. This utilitarian determination is clearly discerned to be by no means necessarily coincident with the settlement towards which competition tends. For instance, the 'vrai prix,' in Condillac's sense, as determined by the play of supply and demand in the labour market, might be such that the *entrepreneur* class should take the lion's share, leaving the labourer a bare and painful subsistence; but there is no ground to believe that this is the best possible arrangement. From an abstract point of view it is by no means evident that a free labour market 'is the only way to equity, that any interference with it must involve injustice.'[1] Nor need it appear 'a great fundamental principle—as inevitable in its action as gravitation—that a fair day's wages for a fair day's labour is determined by the proportion which the supply in the market bears to the demand.'[2] It may be true indeed, in a practical sense, that perfect competition is 'not less harmonious and beneficent in its operation than gravity';[3] but theoretically it is tenable that there is an adjustment of contracts more beneficent than that which the mechanical play of competition tends to establish (l).

To introduce these philosophical conceptions of utilitarianism will doubtless seem irrelevant to those who are immersed in the details of business. But the practical man should be reminded that in other spheres of action, politics and morals, the principle of utility, however badly received at first, has exercised a great influence—though doubtless not so great as was expected by the theorists of Bentham's school, and needing to be largely tempered with common sense.

Such, I think, are the principal points at which mathematical reasoning is capable of being applied to political economy. In estimating the use of this method it is natural to take as our standard the helpfulness of mathematics in other departments of science.

As compared with mathematical physics, the mathematical theory of Political Economy shows many deficiencies. First, there is the want of numerical data, which has been already noticed. It is true that there is a faint hope of obtaining what Jevons too confidently expected, statistical data for the relations between demand and price. It is true also that in the higher mathematics conclusions which are quantitative without being numerical are more frequent than is usually supposed. Some political economy is as exact as some mathematical physics. The fields cultivated by Section A and Section F may overlap, but it must be admitted that the best part of our domain corresponds to what is the worst part of theirs. If you enquire as to the products of our inferior soils, we must confess, if we do not wish to conceal the nakedness of the land, that over a large portion of our territory no crop is produced. We are employed only in rooting out the tares which an enemy has planted. Much of our reasoning is directed to the refutation of fallacies, and a great part of our science only raises us to the zero point of nescience from the negative position of error. 'Sapientia prima stultitiâ caruisse.' In this introductory portion of Political Economy we have seen that the mathematical method is likely to be serviceable.[4]

It is not to be supposed, however, that the work of our Section is wholly destructive; that like the islanders of whom it was said that they earned a precarious livelihood by washing one another's clothes, so we are occupied only in mangling each other's theories. Like imprudent sectaries, by our mutual recriminations we have obscured the virtues common to our profession. What Jevons said of Cairnes, that his own opinions were much more valuable than his objections against other people's opinions, is true of Jevons himself and other controversial economists. Now, this possibility of mutual misunderstanding by persons who are both in the right is connected with a circumstance which it is not irrelevant here to notice. It is that in our subject, unlike Physics, it is often not clear what is the prime factor, what elements may be omitted in a first approximation. One writer on Rent may emphasise distance from the centres of population as the main attribute, and introduce fertility of soil as a perturbation of the abstract result given by the

[1] Danson.
[2] Rupert Kettle on *Arbitration*.
[3] Walker, *Political Economy*.
[4] See above, p. 676.

first view. Another fixes attention on the powers of the soil, and allows for other elements, as for friction. So, in the theory of Money, the state of credit or the quantity of metal have each been regarded as the prime variable.[1] It need not be pointed out how unfavourable to exact science is such a state of the subject-matter. Imagine an astronomer hesitating whether in the determination of Jupiter's movements the sun or the planet Saturn played the most important part. That is the condition of many of our speculations.

It will not be expected that from such materials any very elaborate piece of reasoning can be constructed. Accordingly another point of contrast with mathematical physics is the brevity of our calculations. The whole difficulty is in the statement of our problems. The purely computative part of the work is inconsiderable. Scarcely has the powerful engine of symbolic language been applied when the train of reasoning comes to a stop. The case is like that of the swell in 'Punch,' who, about to enter a hansom, enquires solicitously of the driver whether he has got a good horse. 'Yes, sir; very good 'oss.' 'Aw—then dwive to next door. However, our road, though short, is so slippery as to require every precaution.

It follows that in Economics, unlike Physics, the use of symbols may perhaps be dispensed with by native intelligence. It must be admitted that the correct theory of value has been rediscovered by Menger, and restated by his follower, Böhm-Bawerk, without the explicit use of mathematics. Without the law, they have done by nature the things contained under the law. Still, under a higher dispensation, they might have attained greater perfection. Nor can equal accuracy be ascribed to all the followers of Menger. Nor is the terseness which comes of mathematical study a characteristic of this Austrian school (*m*).

Another point of contrast between the mathematical science of the physicist and the economist is that the former appeals to a larger public. Mathematics is as it were the universal language of the physical sciences. It is for physicists what Latin used to be for scholars; but it is unfortunately Greek to many economists. Hence the writer who wishes to be widely read—who does not say, with the French author, *J'imprime pour moi*—will do well not to multiply mathematical technicalities beyond the indispensable minimum, which we have seen reason to suppose is not very large. The parsimony of symbols, which is often an elegance in the physicist, is a necessity for the economist. Indeed, it is tenable that our mathematical constructions should be treated as a sort of scaffolding, to be removed when the edifice of science is completed. As Professor Marshall, one of the highest authorities on this subject, says: 'When a man has cleared up his mind about a difficult economic question by mathematical reasoning, he generally finds it best to throw aside his mathematics and express what he has to say in language that is understanded of the people.'[2] Upon this view mathematical discipline might be compared to grammar or to the study of classical literature, which it is profitable to have learnt thoroughly, while it is pedantic to obtrude one's learning.

From these considerations it may appear that our little branch of learning is of quite a rudimentary form. The solid structure and regular ramifications of the more developed mathematical sciences are wanting. A less unfavourable contrast would be presented if we compared our method, not with applied mathematics generally, but with that particular branch of it which comes nearest to ours in its proximity to human interests—the use of the Calculus of Probabilities in social statistics.

There is really only one theorem in the higher part of the calculus, but it is a very difficult one, the theory of errors, or deviation from averages. The direct applications of this theory to human affairs are not very considerable. Perhaps the most conspicuous example is afforded by an investigation to which, if I had undertaken to review the work done in our subjects during the past year, I ought to have directed particular attention—Mr. Galton's rigid proof of the fact and

[1] Compare Cournot: 'Ce que l'un néglige dans une première approximation comme un fait secondaire et accessoire, un autre le regardera comme le fait principal et dominant.'—*Principes*, Book iv., chap. 7.

[2] *Academy*, June 18, 1881.

amount of *regression*, or reversion, in children compared with parents, and other relationships.

But, beyond the isolated instances in which the theory of deviations is applied in social statistics with the same strictness and cogency as in physics, there is a wide zone of cases in which the abstract theory is of use as giving us some idea of the value to be attached to statistical results. Mr. Galton justly complains of the statisticians who 'limit their inquiries to averages, and do not revel in the more comprehensive views' of the deviations from averages. 'Their souls seem as dull to the charm of variety as that of the native of one of our flat English counties, whose retrospect of Switzerland was that, if its mountains could be thrown into its lakes, two nuisances would be got rid of at once.' But great caution is required in transferring the Theory of Errors to human affairs; and the Calculus of Probabilities may easily be made, in Mill's phrase, the 'opprobrium of mathematics.'

Now, in all these respects there is a considerable resemblance between the higher parts of the two branches of science which are cultivated in this Section. It may be said that in pure economics there is only one fundamental theorem, but that is a very difficult one: the theory of Bargain in a wide sense. The direct application of mathematical reasoning is, as we have seen, limited—more limited, I think, than the corresponding function of the higher statistics. But, on the other hand, the regulative effect, the educational influence, of studies like those of Cournot and Jevons are probably very extensive.

How extensive, it would be difficult to decide without defining the limits of a province within which our special subject is included—the use of abstract reasoning in Political Economy. Now, on this vexed question, and with reference to the heated controversy between the Historical and the Deductive schools, the mathematical economist as such is not committed to any side. It may be dangerous to take wide general views; it may be better to creep from one particular to another rather than ascend to speculative heights. Our only question here is whether, if that ascent is to be made, it is better to proceed by the steep but solid steps of mathematical reasoning, or to beguile the severity of the ascent by the zigzag-windings of the flowery path of literature. It is tenable that the former course is safest, as not allowing us to forget at what a dangerous height of abstraction we proceed. As Prof. Foxwell has well said,[1] with reference to the mathematical methods in the hands of Jevons and Prof. Marshall, 'It has made it impossible for the educated economist to mistake the limits of theory and practice, or to repeat the confusions which brought the study into discredit and almost arrested its growth.'

I trust that I have succeeded in distinguishing the question what is the worth of abstract reasoning in Political Economy from the much more easily answered question whether, if it is worth doing, it is worth doing well.[2] The mathematical economist is concerned to separate his method from that mathematical and metaphysical reasoning which Burke repudiates as inapplicable to human affairs; from that abstract method which he has in view when he says:—'The geometricians . . . bring from the dry bones of their diagrams . . . dispositions that make them worse than indifferent about those feelings and habitudes which are the supports of the moral world.'[3] Burke is referring to the Jacobin philosophers; but our withers are unwrung, if similar words should be applied to some of the 'sophisters and economists' of a later generation. Just as a political party, if popularly suspected of complicity with crime, would do well to take every opportunity of clearing themselves from that imputation, so the mathematical economist is called on to disown

[1] In his important letter on 'The Economic Movement in England' in the *Quarterly Journal of Economics* for October 1888.

[2] Cf. Prof. Foxwell, *loc. cit.* 'What the new school protest against is first the unscientific and meagre way in which deduction was used. In their view, though it is worth while to study, and therefore worth while to study accurately, the workings of private interest under a system of competition, yet human nature is not all self-interest . . .'

[3] *Letter to a noble Lord.*

emphatically all sympathy with the flagrant abuses to which the injudicious use of abstract reasoning is undoubtedly liable.

To continue the comparison which I was instituting between the mathematical theory of Economics and the Calculus of Probabilities, they have one very unpleasant property in common—a liability to slips. As De Morgan says,[1] 'Everybody makes errors in Probabilities at times, and big ones.' He goes on to mention a mistake committed by both Laplace and Poisson, the ineptitude of which he can only parallel by the reasoning of a little girl whom he had called a 'daughter of Eve'; to which she retorted, 'Then you must be a daughter of Adam.' It is not to be concealed that economic reasoning, even in its severest form, is sometimes equally inconsequent. I should have hesitated to assert that Cournot has made some serious mistakes in mathematics applied to Political Economy, but that the authority of the eminent mathematician Bertrand[2] may be cited in support of that assertion.

Again, the more abstract theories of Value and of Probabilities seem to resemble each other in their distance from the beaten curriculum. Each forms, as it were, a little isolated field on the rarely crossed frontier and almost inaccessible watershed between the moral and the physical sciences.

The same character of remoteness belongs perhaps to another province, which is also comparable with ours—the mathematical side of Formal Logic, the symbolic Laws of Thought which Boole formulated. There was a certain congruity between Jevons's interest in his logical machine and in what he called the 'Mechanics of Industry.' But I venture to regard the latter pursuit as much more liberal and useful than any species of syllogism-grinding.

If you accept these parallels, you will perhaps come to the conclusion that the mathematical theory of Political Economy is a study much more important than many of the curious refinements which have occupied the ingenuity of scientific men; that as compared with a great part of Logic and Metaphysics it has an intimate relation to life and practice; that, as a means of discovering truth and an educational discipline, it is on a level with the more theoretical part of Statistics; while it falls far short of Mixed Mathematics in general in respect of that sort of pre-established harmony between the subject-matter and the reasoning which makes Mathematical Physics the most perfect type of applied science.

But we must remember—and the mention of the Theory of Probabilities may remind us—that any such judgment is liable to considerable error. We cannot hope to measure the utility of a study with precision, but rather to indicate the estimate on either side of which competent judges would diverge—a central point, which will be found, if I mistake not, equally removed from the position of Gossen, who compares the new science to astronomy, and the attitude of Dr. Ingram towards the researches which he regards as nothing more than 'academic playthings, and which involve the very real evil of restoring the metaphysical entities previously discarded.'[3]

One more general caution is suggested by another of the technical terms which we have employed. What we are concerned to discover is not so much whether mathematical reasoning is useful, but what is its 'final utility' as compared with other means of research. It is likely that a certain amount of mathematical discipline—say as much as Mr. Wicksteed imparts in his excellent 'Alphabet of Economic Science'—is a more valuable acquisition to a mind already stored with facts than the addition of a little more historical knowledge.

But, in reverting to the subject of final utility, I am reminded that Presidential Addresses, like other things, are subject to this law; and that a discourse on method prolonged beyond the patience of the hearers is apt to become what Jevons called a *discommodity*.

[1] Writing to Sir W. R. Hamilton (*Life of Hamilton*, by R. Graves, vol. iii.)

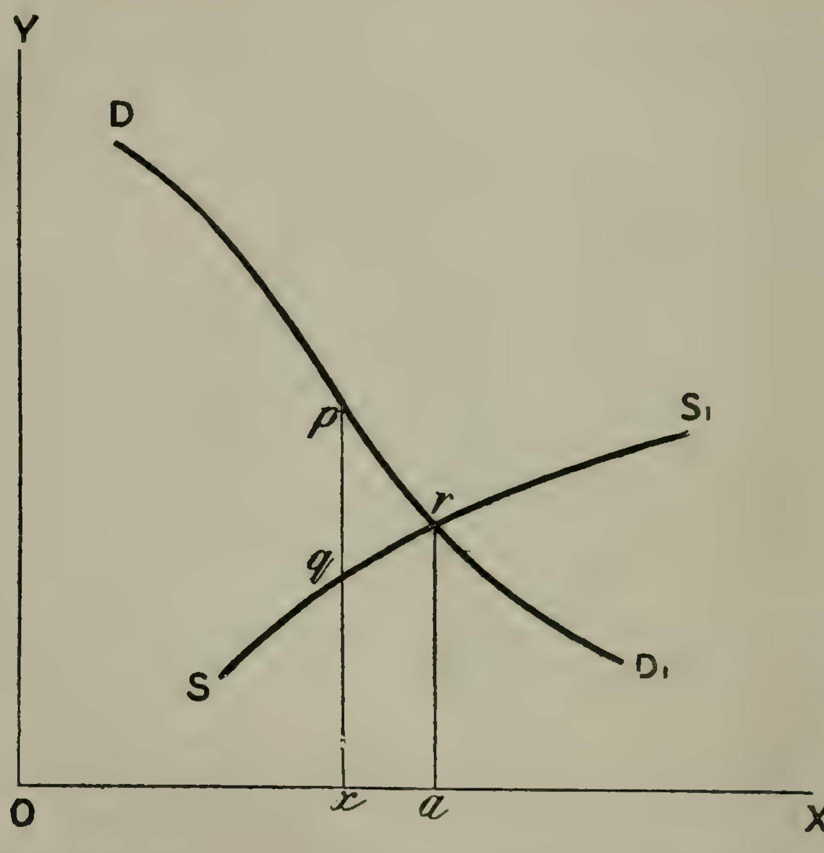
[2] *Journal des Savants*, 1883. I hope to show on some future occasion that M. Bertrand's censures of Cournot and Professor Walras are far too severe.

[3] See the passage relating to Jevons in the article on Political Economy in the *Encyclopædia Britannica*, 9th edition.

NOTES.

(*a*) Simple Exchange.—The simplest case of Exchange is where there are two large groups of uncombined individuals dealing respectively in two commodities, *e.g.*, corn and money. To represent the play of Demand and Supply, let any abscissa, Ox in Fig. 1, represent a certain price, and let the quantity of commodity demanded at that price be xp. The locus of p may be called the Demand-curve. Similarly, xq represents the quantity offered at any price, Ox; and the locus of q is called the Supply-curve. The price Oa, at which the demand is just equalled by the supply, is determined by the intersection of these curves. This is Cournot's construction. The converse construction, in which the abscissa stands for quantity of commodity, the ordinate for price, is employed by Mr. Wicksteed in his excellent 'Alphabet of Economic Science.'

Fig. 1.



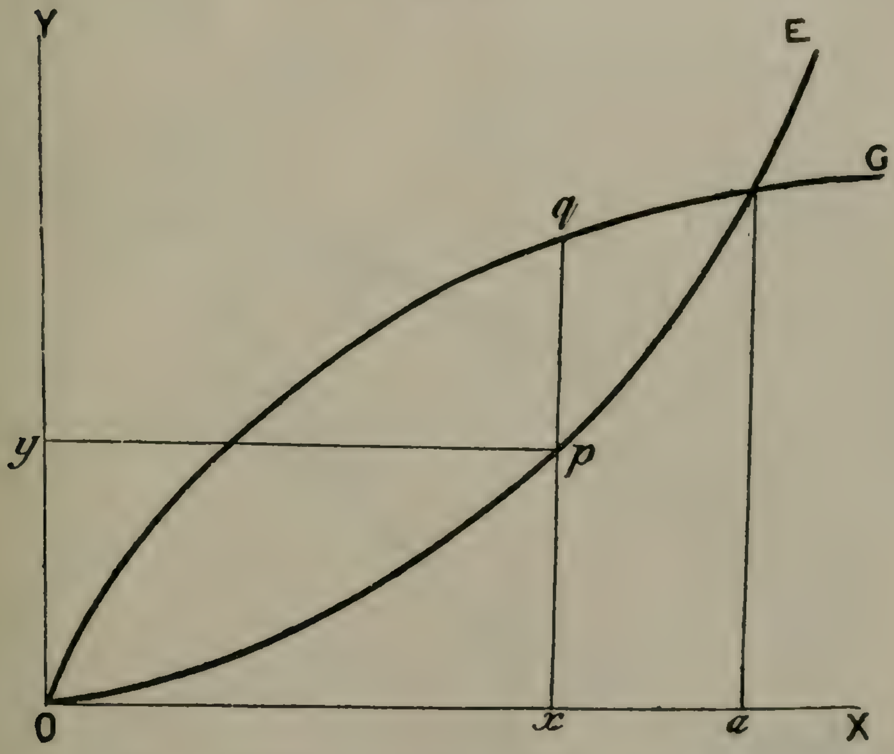
The diagrammatic representation which most closely corresponds to Jevons's formulæ is that which the present writer, after Professor Marshall, and Messrs. Auspitz and Lieben, independently, have adopted. In this construction the two co-ordinates respectively and symmetrically represent the quantities of the two commodities exchanged, the *quid* and the *pro quo*. For instance, Fig. 2 may represent the state of Supply and Demand in the international market between Germany and England. The curve OE denotes that in exchange for any amount of 'linen,' Oy, England is prepared to supply the quantity of 'cloth' yp ($=$ Ox); or, in other words, that in exchange for the quantity Ox of cloth England demands xp ($=$ Oy) of linen. The curve OG is similarly related to Germany's supply and demand. The position of equilibrium is determined by the intersection of these curves.

(*b*) Variations in Supply.—Suppose, as Mill supposes ('Pol. Econ.,' Book iii., ch. 18, § 5), that there has occurred an improvement in the art of producing Germany's

export, linen. The altered conditions of supply may be represented by the displaced curve OG′, Fig. 3, indicating that whereas before the improvement Germany in exchange for any quantity, Ox, of cloth offered only xq, she now offers xq'. The effect of the improvement on the rate of exchange will depend upon the form of the curve OE beyond the point r. If the intersection of the curve OE is at r, vertically above r, we have the case where, as Mill rather awkwardly says, the demand of England for linen increases 'in the same proportion with the cheapness.' The other cases in which the demand for linen—and accordingly the price, so to speak, of cloth in linen—are increased more or less than the cheapness, are represented by the points of intersection r_2, r_3.

The same construction may be used to represent the effect on the rate of exchange produced by a tax on exports or imports. Let OG′ now represent the undisturbed condition of supply, and let OG be what this curve becomes when displaced by a tax on Germany's exports. According to the position of the original intersection, whether at r_1, r_2, or r_3, we have the three cases distinguished by Mill. (Book v. ch. 4, § 6.)

FIG. 2.



Again the same construction may be used to facilitate the comprehension of the theory of International Trade which Professor Sidgwick has recently proposed. Let the curves OE and OG′ represent the conditions of supply and demand, on the hypothesis that cost of transport is annihilated, that England and Germany are in juxtaposition. Now restore the abstracted sea, and the altered conditions of Supply and Demand *in a market on the English shore* will be represented by the change of OG′ to OG. According to the form of the curve OE the different effects on the rate of exchange are visible at a glance. (Cf. Sidgwick, 'Pol. Econ.,' Book ii., ch. 2, § 3.)

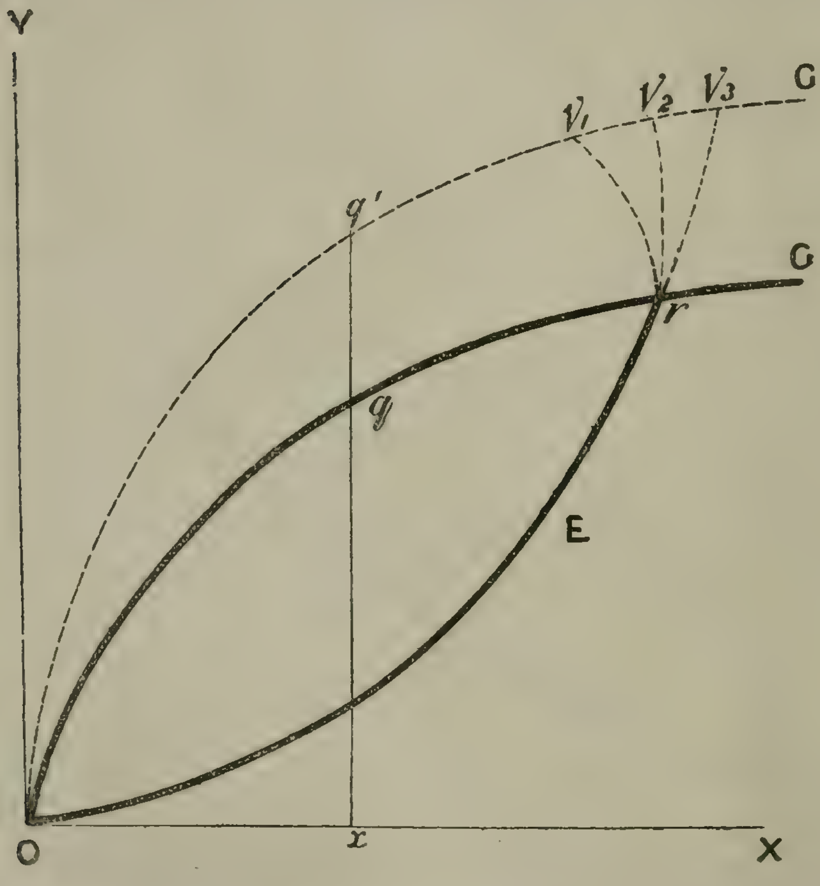
(*c*) GAIN OF TRADE.—To measure the variations in the advantage accruing from trade by the variations of price—or more generally rate of exchange—is a confusion which could hardly have occurred to the mathematical economist. The simplest method of illustrating the gain of trade is that proposed by Messrs. Auspitz and Lieben. In Fig. 4, let On be the locus of a point t, such that a certain individual in exchange for the quantity Ox of one commodity will just be willing to give the quantity tx of another commodity, will neither gain nor lose by that bargain. Then,

if he obtain Ox in return for only rx, he is a gainer by that bargain to the extent of tr. The curve thus defined is called the *Utility-curve.*

Now add properly the Utility-curves for all the individuals of a community, and we obtain what may be called a Collective Utility-curve. There is a peculiar propriety in taking one axis, say the ordinate, to stand for Money. Let ON then in Fig. 5 be the Collective Utility-curve, in this sense, for the German community with respect to cloth. Let OG represent the demand of Germany for cloth, as before, except that the ordinate now stands for money, not linen. And let OE represent the supply of cloth in exchange for money on the part of England. Then the gain to Germany of the trade with England is represented by the vertical distance tr.

Now let Germany impose a tax on the import of cloth. The effect of the tax will be to displace the supply-curve in the manner indicated by the dotted curve OE′. Let r'

FIG. 3.



be the new point of intersection between the Demand- and (displaced) Supply-curve. The gain to Germany in the way of trade is now $t'r'$. To which is to be added the tax $r's$ accruing to Germany. Since $t's$ may very well be greater than tr, Germany may gain by the imposition of the tax.

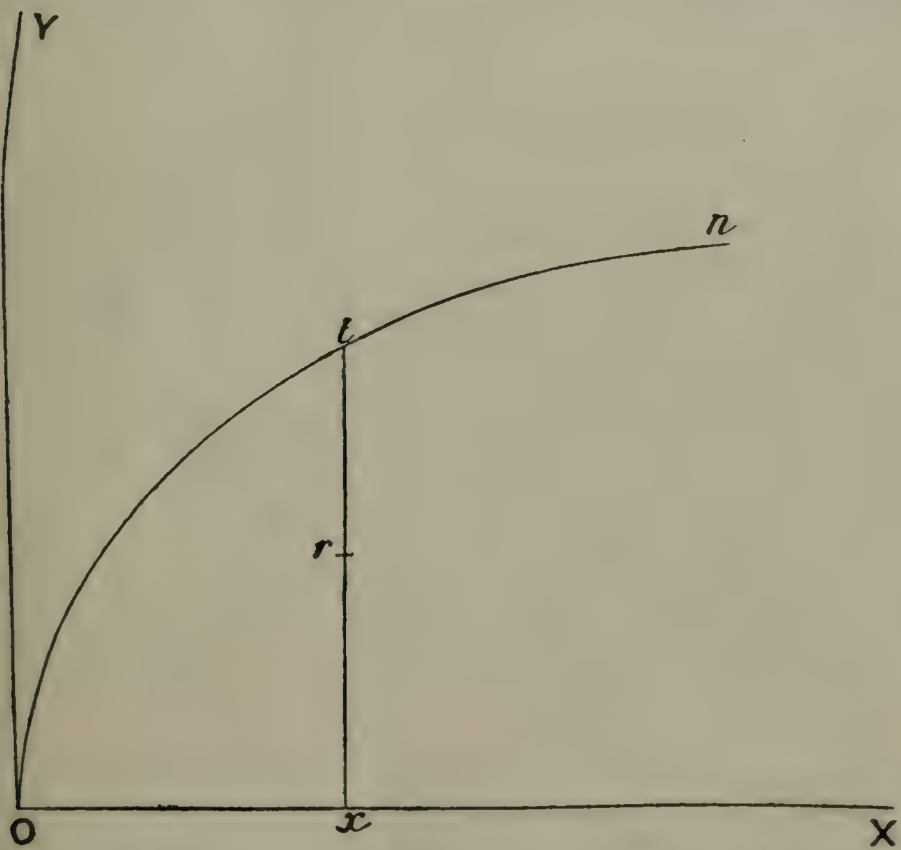
What difficulties the reader may feel about this proposition will disappear on reference to Messrs. Auspitz and Lieben's beautiful and original reasoning ('Theorie der Preise,' §§ 80-82). In the light of their constructions it will be at once seen what conditions of supply and demand are favourable to the endeavour of one nation to gain by taxing the imports from (or exports to) another. It will be noticed that the particular supposition entertained by Professor Sidgwick (Book iii. ch. 5, § 2)—that the quantity consumed of the taxed import is constant—is not essential.

It may be observed that the *Utility-curve* is a particular case of the '*Indifference-curve*' employed by the present writer ('Mathematical Psychics,' p. 21). Also the

lines tr and $t's$ are particular cases of the 'preference-curve' (*Ibid.* p. 22). If these more general conceptions are employed, the demonstration will not require that we should put the ordinate for Money, regarded as a constant measure of utility. The interpretation assigned to the curves OG and OE in our second and third figures may still stand.

(*d*) ECONOMIC EQUILIBRIUM.--By analogy with well-known physical principles, economic equilibrium may be regarded as determined by the condition that the advantage of all parties concerned, the integrated utility of the whole economic system, should be a *maximum*. This *maximum* is in general subject, or in technical phrase *relative*, to certain conditions; in particular what Jevons called the 'law of indifference,' that in a market all portions of a commodity shall be exchanged at the same rate. But occasionally this condition is suspended: as often as we take

FIG. 4.



what may be called a socialistic or utilitarian view as distinguished from that incommensurability of pleasures appertaining to different persons, which Jevons in a remarkable passage of his *Theory* (p. 15) has postulated. It will be found that this postulate must be abandoned when we consider the gain of trade, as in our note (*c*), or the theory of combinations, as in note (*l*), and on other occasions.

In general, the first condition of a maximum, that the first term of variation should vanish, gives the Jevonian equations of exchange, the demand curves of other writers.

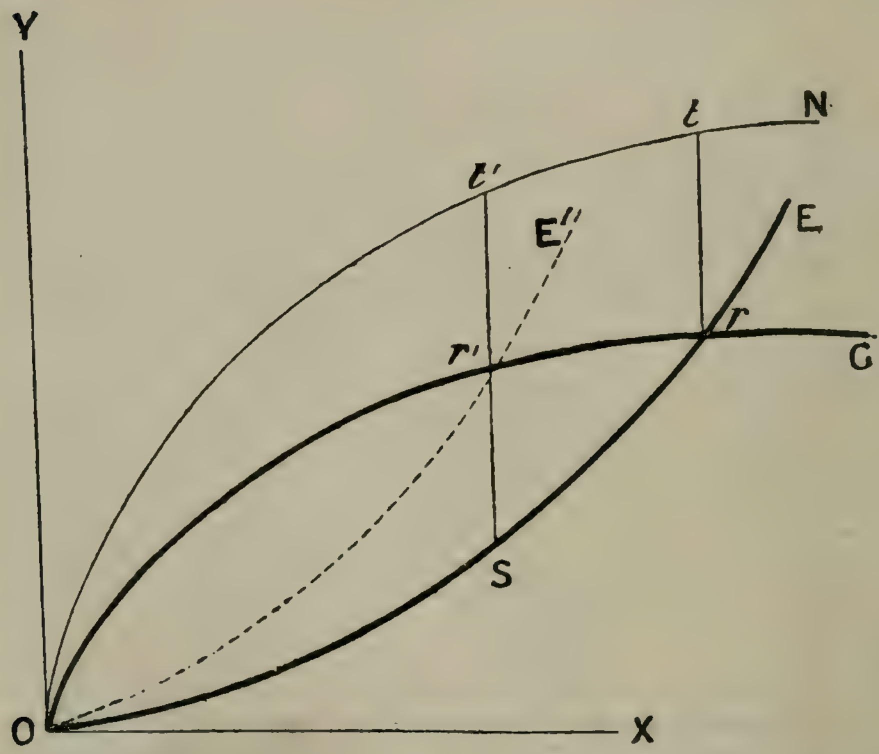
The second condition of a maximum, that the second term of variation should be negative, finds its fulfilment in certain well-known propositions which involve the conception of a decreasing rate of increase, viz., the law of diminishing returns, the law, or laws, of diminishing utility and increasing fatigue.

For some propositions it is proper to take account not only of the sign, but also the magnitude, of the second differential of utility. Thus when Professor Walker is

contending that in case of 'any increase of product resulting from the introduction of any new force into industry,' the whole increment will fall to be added to the share of the working class ; he argues, quite correctly upon his premisses, that if the improvement does not 'increase the amount of tools and supplies required in production'—since 'there is no greater demand for capital in the case supposed— . . . . there can be no increase in the rate or amount of interest' ('Quarterly Journal of Economics,' 1887, pp. 283, 284). Analytically we should find that the variation in the rate of interest due to the disturbance of equilibrium, say $\Delta\iota$, was indefinitely small as compared with the variation in the rate of wages, say $\Delta\omega$, because the decrease in the rate at which the utility of capital increases is indefinitely great. The argument requires that this second differential should be infinite at the position of equilibrium.

(*e*) COMPLEX EXCHANGE is the general case of Simplex Exchange above analysed. We have now several, instead of two, categories of dealers and commodities. In both cases equilibrium is determined upon the principle that each individual seeks

FIG. 5.



to maximise his own advantage, subject to the conditions (1) that in a market there is only one price for any article, and (2) that all which is bought is sold, and all which is sold is bought. Let there be m dealers and n articles. And the first article being taken as the measure of value, let the prices of the remaining articles be $p_2, p_3, \ldots p_n$. Let the quantities of commodities bought or sold by any individual, say No. r, be $x_{r1}, x_{r2}, \ldots x_{rn}$; each variable with its sign : *plus*, if bought, *minus*, if sold. Let the advantage of the individual, regarded as a function of his purchases and sales, be $\psi_r(x_{r1}, x_{r2} \ldots x_{rn})$. There is sought the system of values assigned to the variables for which this function is a maximum, subject (α) to the condition which follows from the first assumption above made : $x_{r1} + p_2 x_{r2} + \&c. + p_n x_{rn} = 0$. In order to determine the maximum of ψ_r subject to this condition, we obtain (β) by the Calculus of Variations $(n-1)$ equations of the form—

$$\left(\frac{d\psi_r}{dx_{r1}}\right) = \frac{1}{p_2}\left(\frac{d\psi_r}{dx_{r2}}\right) = \ . = \frac{1}{p_n}\left(\frac{d\psi_r}{dx_{rn}}\right)$$

(with certain conditions as to the second term of variation). To which is to be added the equation (α). We have thus n equations relating to the r^{th} individual. The same being true of each of the m individuals, we have in all $m\,n$ equations of the forms (α) and (β). We have also (γ), from the condition that everything which is bought is sold, and conversely, n equations of the following form: $x_{1s}+x_{2s}+\&c.+x_{ms}=0$.

But of the $(m+n)$ equations of the forms (α) and (γ) only $(m+n-1)$ are independent. For adding the m equations of the form (α) we have:

$$\left.\begin{array}{l}(x_{11}+x_{21}+\ .\ .\ .\ +x_{m1} \\ +p_2(x_{12}+x_{22}+\ .\ .\ .\ +x_{m2} \\ +\quad -\quad -\quad -\quad - \\ +p_n(x_{1n}+x_{2n}+\ .\ .\ .\ +x_{mn}\end{array}\right\}=0.$$

Now, if any $(n-1)$ of the equations of the form γ, say all but the first, are given, then in the last written equation the coefficients of $p_2\ .\ .\ .\ .\ p_n$ vanish. Therefore the first equation of the form (γ), viz. $x_{11}+x_{21}+\&c.+x_{m1}$, is also given. We have thus $mn+(n-1)$ equations to determine $mn+(n-1)$ quantities, viz. the x variables, which are mn in number, and the $(n-1)$ p's.

The great lesson to be learnt is this. The equations are *simultaneous*, and their solution *determinate*. That the factors of economic equilibrium are simultaneously determined is a conception which few of the literary school have received. The reader is referred to Prof. Walras' 'Leçon' 12 ('Econ. Pol.' 2nd ed.) for a lengthier exposition, and for a more accurate one to Messrs. Auspitz and Lieben's Appendix IV.

(f) Commercial Competition.—Abstracting that change of occupations which Cairnes ascribed to 'Industrial' as distinguished from 'Commercial,' competition (comp. Sidgwick's 'Pol. Econ.' book ii. ch. 1), let us suppose that the x's of the last note, which primarily denoted commodities ready for immediate consumption, include also agencies of production, (the use of) land, labour, and capital. We may conceive *entrepreneurs* buying these agencies from landlords, labourers, and capitalists, and selling finished products to the public. We have thus the appropriate idea of rent, wages, interest, and (normal) prices determined *simultaneously* (in the mathematical sense).

In a primary view of complex exchange it is proper with Jevons to regard each portion of commodity sold, each negative variable, say $-x_{rs}$, as a deduction from an initial store, say ξ_{rs}. But when we consider production, we regard ξ as a function of the outlay of the *entrepreneur*. Supposing that the *entrepreneur* confines himself to the production of a single article, let the gross produce, in money, after replacing capital, be $f_r(c_r,\ l_r)$, where f_r is a function depending on the individual's skill, energy, opportunities, &c., c_r is the amount of capital borrowed by him, and l_r the number of acres of a certain quality which he rents. The net produce is obtained by deducting from this quantity the payments $c_r\iota+l_r\rho$, where ι is the rate of interest and ρ is the rent per acre. Thus the advantage which the *entrepreneur* seeks to maximise is of the form

$$\psi_r(x_{r1},\, x_{r2}\ .\ .\ .[f_r(c_r,\, l_r)-c_r\iota-l_r\rho]-x_{rr}\,p_{rr},\ .\ .\ .);$$

whence $\dfrac{df_r}{dc_r}=\iota$ and $\dfrac{df_r}{dl_r}=\rho$. The first of these equations expresses a well-known proposition regarding the final utility of capital. The second equation expresses a less familiar condition with respect to the number of acres which will be rented on an ideal supposition of the homogeneity and divisibility of land above the margin of cultivation.

What then, and where, is the Ricardian theory of rent? Its symbolic statement is $l_r\rho=f(c_r,\, l_r)-f(c_r,\, o)=f_r(c_r,\ l_r)-c_r\times\iota$; where $f(c_r, o)$ is the gross produce of c_r capital laid out by the individual numbered r, on land below the margin obtainable for nothing in as large quantities as desired. It will be found that these equations postulate that the quantity of land above the margin is small as compared with the number of applicants, and that $f(c_r,\, o)$ is identical with $c_r\times\iota$, which are the common Ricardian assumptions. The validity of these assumptions as a first approximation, the need of correction where greater accuracy is required (truths which some minds seem incapable of holding together), have been admirably pointed out by Mr. Sidgwick ('Pol. Econ.,' Book ii. chap. 7, § 2). The second approximations made by him may be usefully expressed in the symbols which have been proposed, or rather in those which the student may construct for himself. I do not put

forward those which occur to me as the best—if, indeed, there is any absolutely best in the matter of expression. For some purposes it would have been proper to take account of the various qualities of land (as I have elsewhere done—'Brit. Assoc. Rep.' 1886). For other purposes it would be well to put labour hired by the *entrepreneur* as an independent variable. When this or any other variable is omitted we are to understand that there is implied the best possible arrangements with respect to the variables which are not expressed. The nature of this implication is shown in the following note.

(*g*) So far we have been taking for granted that the *entrepreneur* does his best, without reference to the motives acting upon him, the pleasures procurable by the sale of his product. Formally it would be proper to take account that the utility-function ψ_r involves the *effort*, say e_r, explicitly, as fatigue diminishes advantage, and implicitly, as exertion increases production. Corresponding to the new variable we have a new equation, the complete differential of ψ_r with reference to e_r, say $\left(\frac{d\psi_r}{de_r}\right)+\left(\frac{d\psi_r}{df_r}\right)\frac{df_r}{de_r}=o.$ It is a nice question how far effort should be regarded as an independent variable; how far the essential principle of piece-work prevails in modern industry.

(*h*) Industrial Competition.—The condition that net advantages should be equal in industries between which there is mobility may thus be contemplated. Let us put the advantage of an individual, say No. r, engaged in the occupation s as a function of his net income, the price of the articles on which his expenditure is made, and the disutility of effort. Say $\phi_{rs}\,(\mathrm{f}_{rs}\,(\pi_1, \pi_2 \,.\,.\,.\,.\, e_{rs}), p_1, p_2 \,.\,.\,.\,.\!-\!e_{rs})$; where ϕ_{rs} is a utility-function, not necessarily the same for the same individual in different occupations, since his indulgences may vary with the nature of his employment; f_{rs}—a symbol not identical with the f of the last but one note—is the individual's net earnings in the business s, involving prices π_1 π_2, &c., of all manner of agents of production, involving also as stated in note g the effort e_{rs}; p_1, p_2 &c., are prices of articles of consumption as a function of which the individual's advantage may be obtained by means of the equations (α) and (β) in note (e)—eliminating the quantities consumed. The last variable in the function ϕ_{rs}, the explicit e_{rs}, has a negative sign prefixed, to indicate that the direct effect of increased fatigue is diminished advantage.

The equation of Net Advantages imports that the advantage, ϕ_{rr}, of the occupation which the individual chooses is not less than ϕ_{rs}, the advantage of any other occupation open to him. It is important to observe that for all occupations the complete differential with regard to e is zero; in symbols $\left(\frac{d\phi}{d\mathrm{f}}\right)\frac{d\mathrm{f}}{de}+\left(\frac{d\phi}{de}\right)=o.$ But this equation conveys no presumption that the final disutility in different occupations is the same that $\left(\frac{d\phi_{rs}}{de_{rs}}\right)=\left(\frac{d\phi_{rt}}{de_{rt}}\right)$. The equation of final disutility holds only where efforts and sacrifices are capable of being applied in 'doses' to any number of occupations. The latter is the only case, I think, contemplated by Jevons in his analysis of Cost of Production ('Theory,' ch. v.). The inquiry, what is meant in general by saying that the cost of production of two articles is equal, must start from right conceptions about Final and Total Utility. But this is not the place to follow up the difficult investigation. I do not attempt here to discuss any matter fully, but only to illustrate the suitability of the subtle language of mathematics to economical discussions.

(*i*) Professor Walker's Theory of Business Profits.—Professor Walker's theory as stated in the 'Quarterly Journal of Economics' for April, 1887, involves the proposition that the remuneration of the lowest, the least gifted employers, is on a level with that of the labouring class. Concerned as we are here with methods rather than results, it is allowable to posit this premiss without expressing an opinion as to its accuracy. It is fortunate not to have to take sides on an issue concerning which the highest authorities are divided, and statistical demonstration is hardly possible.

But, though the expositor of method is not called to dispute the truth of this proposition, he has something to say against the evidence which has been adduced in proof of it. He must enter a protest against the form of the following argument:—

'Let our hypothesis be clearly understood. We assume, first, that there is in a given

community a number of employers, more or fewer, who alone are, by law or by custom, permitted to do the business of that community, . . . or else who are so exceptionally gifted and endowed by nature for performing this industrial function that no one not of that class would aspire thereto, or would be conceded any credit or patronage should he so aspire. Secondly, we assume that neither in point of ability nor opportunity has any one member of this class an advantage as against another . . . all being, we might say, the exact copies of the type taken, whether that should involve a very high or a comparatively low order of industrial power.

'Now, in the case assumed, what would be true of business profits, the remuneration of the employing class? I answer that if the members of this class were few, they might conceivably effect a combination among themselves, and . . . fix a standard for their own remuneration. . . . If, however, the community were a large one, and if the business class . . . were numerous, such a combination . . . would be impracticable, . . . the members of the business class would begin to compete with each other. From the moment competition set in it would find no natural stopping place until it had reduced profits to that minimum which, for the purposes of the present discussion, we call *nil*.

'What, in the case supposed, would be the minimum of profits? I answer: This would depend upon an element not yet introduced into our problem. The ultimate minimum would be the amount of profits necessary to keep alive a sufficient number of the employing class to transact the business of the community. Whether, however, competition would force profits down to this low point would depend on the ability or inability of the employing class to escape into the labouring class. We have supposed that labourers could not become employers; but it does not follow that employers might not become labourers and earn the wages of labourers. . . .' ('Quarterly Journal of Economics,' 1887, p. 270 and context.)

This reasoning will puzzle those who have received the abstract theory of supply and demand as formulated by the mathematical school [above, notes (*a*) and (*d*)]. Because the dealers on one side of a market, as the employers in the labour market, compete against each other without combination, it does not follow that the advantage which they obtain from their bargains is *nil*. The *minimum* to which the play of competition tends is not necessarily small in the sense of a bare subsistence. It is a *minimum* only in the mathematical sense in which every position of equilibrium is a minimum (of potential energy in physics; in psychics, may we say, of potential utility. See note *d*).

Representing the *entrepreneur's* demand for work by the curve O G (fig. 5), where the abscissa measures work done, and the ordinate money payable out of the wages and profit fund, and putting O E for the offer of the workmen, we see that the point *r* may differ to any extent from the Utility-curve O N, which indicates the advantage of a transaction (see note *c*). As far as abstract theory, without specific data, carries us, the competing *entrepreneurs* may make very good bargains. They may be ever so prosperous; they may be, in Burke's fine phrase, 'gambolling in an ocean of superfluity.'

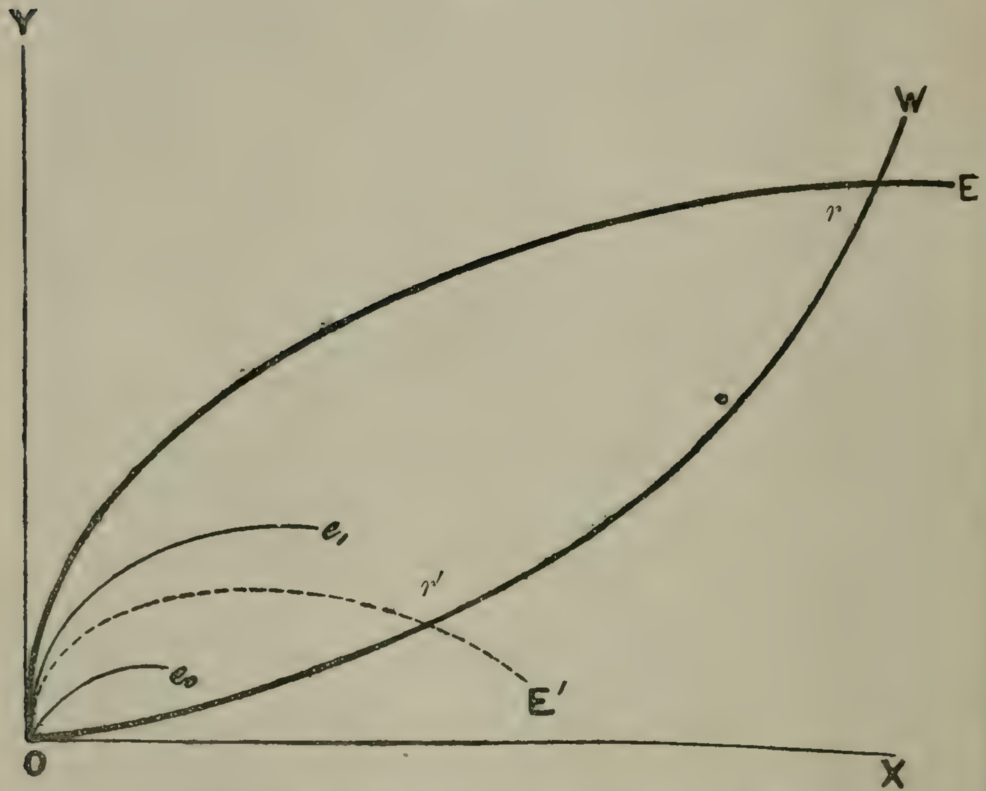
So far, on the hypothesis that neither in point of ability nor opportunity has any one member of this class an advantage as against another. The heterogeneity of faculty will, of course, introduce a graduation of gain. But in this flight of steps it is not necessary that the lowest should be on a level with the grade of common labour. The scale of profits may be a sort of Jacob's ladder, culminating in a paradise of luxury, and having its lowest rung suspended high above the plain of ordinary wages.

Let us suppose, however, that the writer has tacitly made some assumption as to the numbers of the 'numerous' business class relatively to the 'large' community (compare the parallel passages in his 'Political Economy': pars. 280, 236). Still what does the consideration of business profits as rent do more than the received principle of Supply and Demand? If the workmen, believing that in the distribution regulated by competition too much has been assigned to brain and too little to muscle, determine to reduce profits by means of a combination, should they stay their hand because they are told that profits (above the lowest grade) are of the nature of rent? The terms 'rent' and 'margin' may indeed suggest that the extra profits of the abler *entrepreneurs* exactly correspond to their greater ability. It might seem that if, so to speak, we pushed down all the higher faculties to the level of the lowest grade of business power, the diminution of the total distributed, of the wages and profits fund, would exactly correspond to the subtraction from the earnings of the degraded *entrepreneurs*, while everything else remained constant. Conversely it might be argued that the increment of produce due to the existence of superior ability may justly be assigned as extra profit.

But how little appropriate is this precise conception will at once appear from

the annexed diagram. Let OE in fig. 6 represent the *entrepreneur's* demand, OW the workmen's offer of labour, the abscissa representing work done, and the ordinate wages payable out of the wages and profits funds (abstraction being made of interest and rent for land). Let OE be formed by the composition of Oe_0, the collective demand curve for the lowest *entrepreneurs*, and one or more curves, such as Oe_1, appertaining to the *entrepreneurs* of higher ability. Now let us shrink these higher natures to the zero of business ability. The individual demand-curve for each degraded *entrepreneur* will become identical with that from which Oe_0 was formed (by the combination of all the demand-curves for the lowest grade). The new demand-curve will therefore be of the form OE′ intersecting with OW as at the point r'. (Whether the disturbance will stop there will depend upon the nature of the communication between the departments of employer and workman; whether the

FIG. 6.



mobility is one-sided, like that of fluid allowed by a valve to escape from one vessel to another, but not back again—see the end of the passage cited on page 689 from the 'Quarterly Journal of Economics'—or whether the permeation is perfect.) If Oe_0 is small, if the part played in production by the marginal employers is insignificant, it is probable that the annihilation of the higher grades will result in the destruction of the greater part not only of profits, but also of wages.

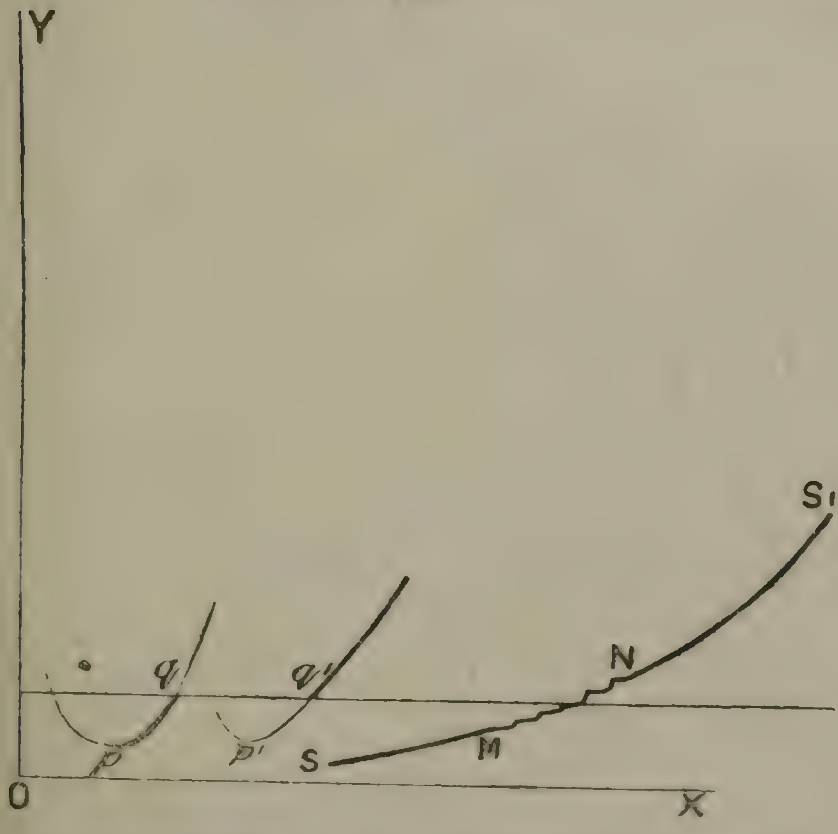
Accordingly it appears in general inexact to say that the 'surplus which is left in the hands of the higher grades of employers . . . is of their own creation' ('Quarterly Journal of Economics,' April 1887, pp. 274–5); if we define their own creation as the difference between the actual produce and that which would have existed if their superior faculties had not been exercised. In that sense (and what other sense is there?) the surplus of the higher grades is likely to be much *less* than their own creation (especially in the case where the marginal employers are relatively few). We seem to have proved too much. But may we not deduce the *quod est demonstrandum*, that actual profits are deserved, from the larger proposition that the *entrepreneurs*' 'own creation' is by a certain amount greater than their profits? No; for that larger proposition is blocked by the antinomy that the workmen (or the

higher grades of them) may by parity claim the greater part of the produce as *their* 'own creation'—what would not have existed but for the exertion of their faculties.

In short, we know no more than we knew at first—viz. that the distribuend is produced jointly by the owners of brain and muscle, that the terms of the distribution are determined by Supply and Demand, and that in this, as in every other market, each more favoured nature enjoys a *rent*, or differential advantage [the nature of which is well illustrated by Messrs. Auspitz and Lieben's construction indicated in our note (*c*)]. That the surplus earning of the superior *entrepreneur* is his own creation is true of the individual, but not of the class; in Division, but not in Composition.

However, Professor Walker may have tacitly made some specific assumptions as to the quantities involved (*e.g.*, the proportion of produce with which the marginal

FIG. 7.



entrepreneurs are concerned); or I may have misinterpreted his statements. Even so, the liability to such misconstruction is a defect in the purely literary method.

It would be easy in the case of less eminent writers to exemplify the part which the mathematical *organon* may play in lopping the excrescences of verbal dialectics. But I must content myself with briefly adverting to one of Prof. Walker's critics, Mr. Sidney Webb. His able paper on the 'Rate of Interest and the Laws of Distribution' appears to me to contain several points deserving of attention; with respect to which mathematical conceptions may assist the reader in distinguishing the original from the familiar, and the true from the misleading.

(1.) Mr. Webb restates the theory formulated by Jevons, that capital is ideally distributed according to the law of 'equal returns to the last increments.' ('Rate of Interest and Laws of Distribution,' by S. Webb, p. 10, 11, 21 of paper reprinted from 'Quarterly Journal of Economics,' Jan. 1888.

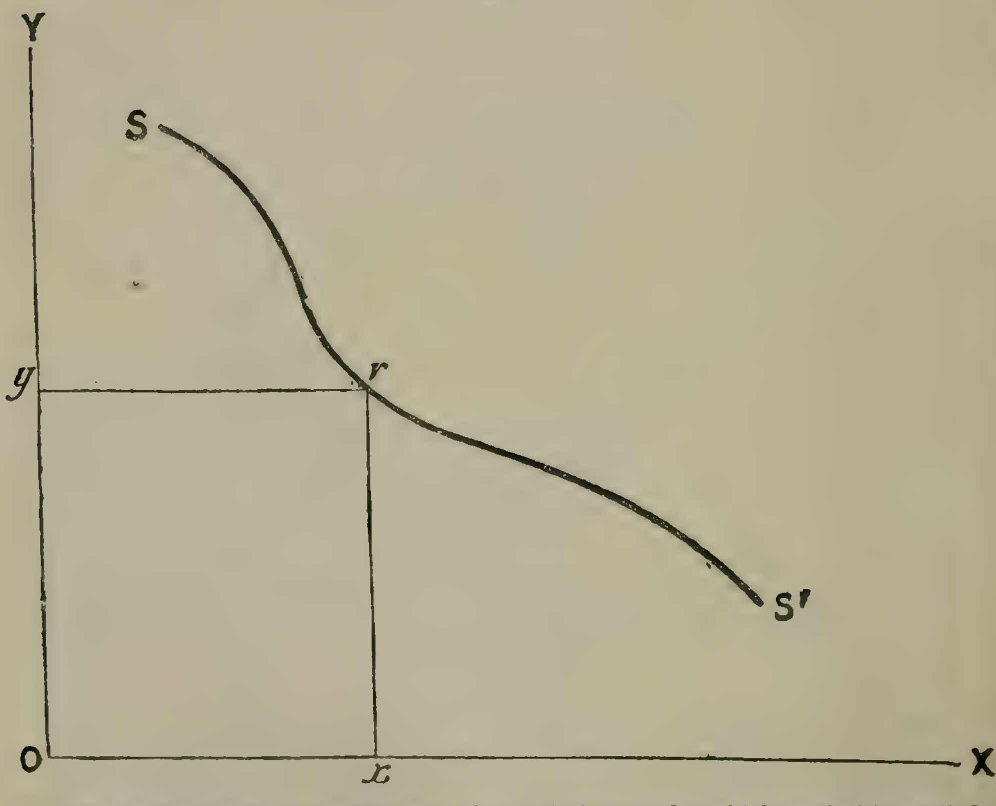
In symbols (see above, note (*f*), p. 687) let the net earning of any individual be $f_r(c_r) - \iota c_r$; where f_r is a function differing for different individuals according to their

faculties and opportunities, c_r is the amount of borrowed capital employed by the individual; ι is the rate of interest; land and labour are not expressed. In equilibrium

$$\frac{df_r(c_r)}{dc_r}=\iota=\frac{df_s(c_s)}{dc_s}=\frac{df_t(c_t)}{dc_t}=\ldots$$

(2.) Again Mr. Webb discerns that the 'law of diminishing returns' is applicable to capital as well as to land (*ibid.*, p. 9, 20, &c.). This is probably a new truth to the literary economist, who will have some difficulty in reconciling it with the *law of increasing returns* received into the text-books. To the mathematician it is evident that, in order to maximise the net earnings $f(c)-\iota c$, not only must the first differential of this expression vanish, but also the second differential $\frac{d_2f}{dc^2}$ must be negative, which is the *law of diminishing returns*. It is quite consistent with the supposition that for certain values of the variable, not admissible as a solution of the problem, $\frac{df}{dc}$ should be positive, agreeably to the *law of increasing returns.*

FIG. 8.



Diagrammatically, let us represent the conditions under which capital is applied by a certain individual, according as the scale of production is large or small, by the curves pq and $p'q'$ in Fig. 7; where the abscissa denotes quantity of capital, and the ordinate the increment of (gross) produce due to an increment of capital. There cannot be equilibrium, unless the increment denoted by the ordinate is just balanced by the sacrifice thereby incurred—in the case which I have supposed the payment of interest. There cannot then, on this supposition, be stable equilibrium, unless the curve is ascending. The descending (dotted) branches correspond to the law of increasing returns. (The explanation of other features in the Figure is given in the next note.)

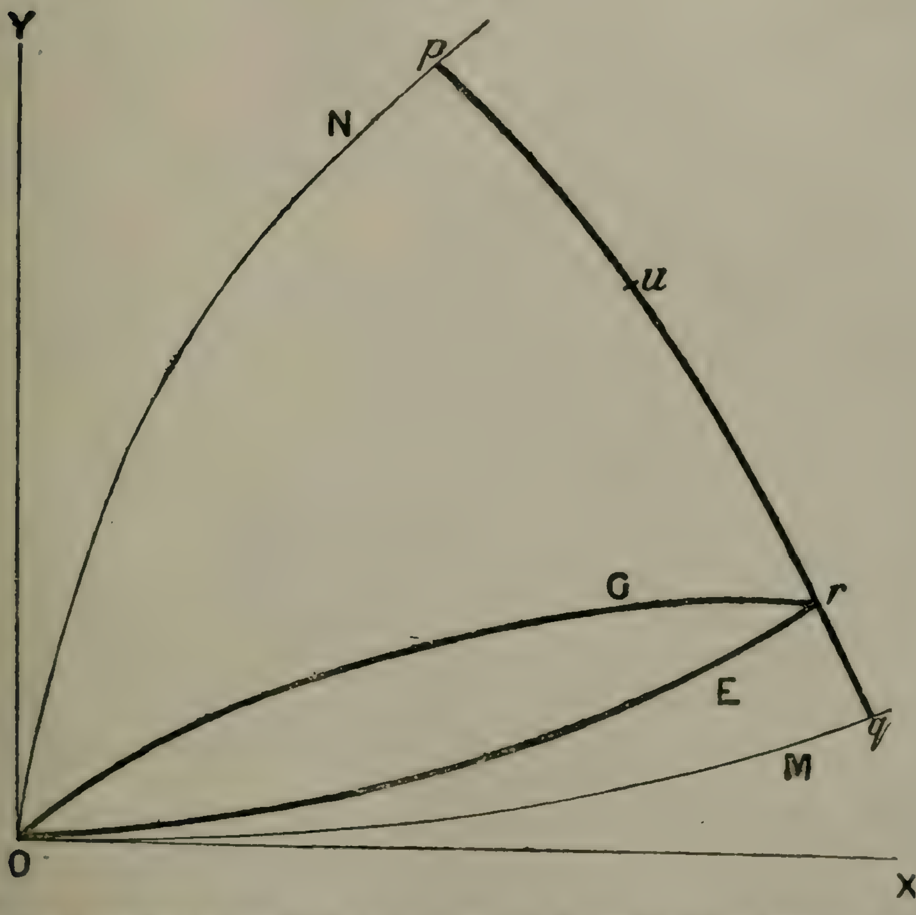
(3.) Mr. Webb dwells much on 'the special industrial advantages not due to superiority of site or skill' which are enjoyed by some individuals. The use of an expression for the product like our f_r may serve at least to keep in mind the existence of such specialities. It also brings into view a difficulty which has not been sufficiently noticed by those who use *rent* in its metaphorical or secondary sense.

Suppose the extra produce is a function involving several variables (or parameters) like Land, Ability, Opportunity. Say $f_r = F(\lambda, \alpha, \omega \ldots)$, where F is a form common to the community, and λ, α, ω denote the quality of land, ability, and opportunity peculiar to the individual. If the extra produce is $F(\lambda\, \alpha\, \omega) - F(o, o, o)$; is $F(\lambda, o, o) - F(o, o, o)$ the 'economic rent' of land; $F(o\, \alpha\, o) - F(o, o, o)$ the rent of ability; $F(o\, o\, \omega) - F(o, o, o)$ the extra produce due to opportunity? (*ibid.*, pp. 16, 17.) If so, the three parts do not make up the whole.

(4.) Anyway, to call the third extra produce *Interest* is very unhappy. Its affinities are evidently with Rent. (Cf. Sidgwick 'Pol. Econ.,' Book ii., ch. 7, § 4.)

(5.) I should not have complained about the use of a term, but that it is connected with Mr. Webb's main contention against Prof. Walker, to which I am unable to

FIG. 9.



attach significance: that 'this, not the "rent of ability" is the real keystone of the arch' (*ib.* p. 17). From the point of view here taken (above, p. 673) this search for the 'keystone' among the factors of distribution is nearly as hopeless as the speculation of the ancients about the real *up* or *down*.

(*j*) DETERMINATENESS OF ECONOMIC EQUILIBRIUM.—To investigate the possibility of there being more than one rate of exchange at which the supply is just carried off by the demand, let us consider the most favourable or, at least, the most familiar case in which there may be two scales of production, and therefore two series of terms on which the producer is willing to deal—two supply curves. Let the two branches in Fig. 7 represent such a double supply-curve, the ordinate denoting price, and the abscissa the quantity of product which is offered at that price by a certain individual. Now, the essential idea or leading property of an individual Supply-curve is that it represents the quantity which the individual will prefer to offer at any given price. Hence the *descending* part of the branches, dotted in the figure, cannot form

a genuine supply curve. For at any point on that part of the locus it is evidently the interest of the individual to increase his production, price being constant. Stable equilibrium, therefore, can exist only on the ascending, the unbroken branches. The thick curve lines in the figure indicate the locus of *greatest possible*, as distinguished from *maximum*, utility. Suppose that at and above the price, corresponding to the point q, it is the interest of the producer to adopt the larger scale of production. Up to that price his industrial dispositions will be represented by the inner curve; on reaching that point he will jump from q to q' and ascend along the outer curve. The locus of greatest possible utility may be called the genuine or effective supply-curve. A similarly shaped supply-curve may exist for other producers. Suppose now all these individual effective supply-curves compounded, and we have the effective supply-curve for the community, SS', which continually trends outwards. This character is not annulled by the existence of steps in the tract MN, corresponding to the prices at which the leap of each individual occurs. *A fortiori* the Demand-curve continually trends outwards like that in Fig. 1 (cp. Auspitz and Lieben). It should seem, therefore, that theoretically on the supposition of enlightened self-interest there is only one rate of exchange at which Supply is just equal to Demand. No doubt there is something to be said on the other side. Suppose the jump from q to q', or from q' to q, involves expense and a breach of habit, which the 'economic man' will not neglect. A little attention will show that in this case the tract MN' of the Collective-curve might break up in two separate branches. Moving from M upwards we should not be on the same locus as from N downwards.

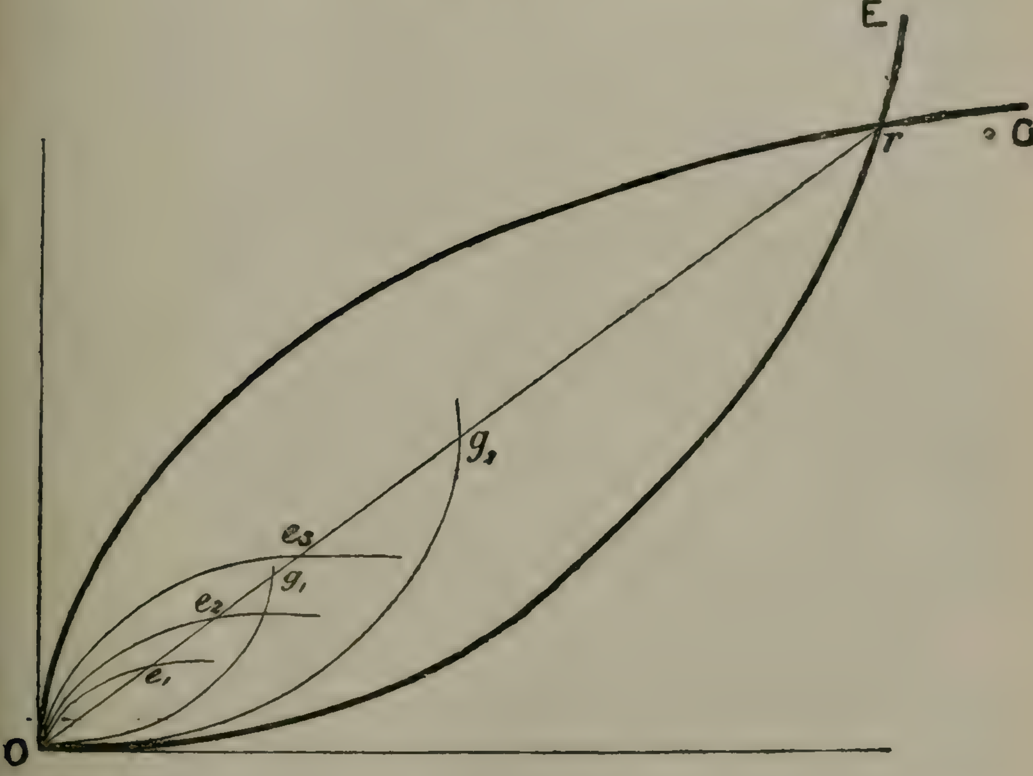
(*k*) ONE-SIDED MONOPOLY.—In Fig. 8 let the curve SS' represent the demand of the public for a monopolised article, the abscissa denoting price, the ordinate quantity. Then, as Cournot shows, if there are no expenses of production the rectangle $Oyrx$ should be a *maximum* ('Recherches,' Art. 25); or rather the *greatest possible*. The solution is not likely to be indeterminate, except in the particular case where the Demand-curve is an equilateral hyperbola. Indeterminateness is similarly exceptional when there are expenses of production (cp. Sidgwick 'Pol. Econ.,' Book ii. ch. 2, § 4).

(*l*) TWO-SIDED MONOPOLY.—In Fig. 9 let Op and Oq represent the curves of constant satisfaction, or indifference curves (above note (*d*); 'Theorie der Preise,' Appendix II.; 'Mathematical Psychics,' p. 21) drawn through O for two individuals or combinations respectively. Then the locus of bargains which it is not the interest of both parties to disturb is the *contract-curve*, pq ('Math. Psych.' *loc. cit.*). At what point then on this curve will the transaction settle down? If we assume that the conditions of a market are retained, the required point is at the intersection of the Supply- and Demand-curves which is on the contract-curve. That is the solution of Messrs. Auspitz and Lieben ('Theorie,' p. 381). It corresponds to the principle laid down by Professor Marshall for the action of arbitrators (referred to above in note 1, p. 675). But Professor Menger, who has a numerical scheme equivalent to a rudimentary contract-curve ('Grundsätze,' pp. 176–8), and Professor Böhm-Bawerk, referring to the 'Spielraum' afforded by the indeterminateness of bargain, recommend to 'split the difference.' Instead of 'equal,' '*equitable*' division has been proposed by the present writer, namely, that adjustment which produces the maximum of utility to all concerned; not subject to the conditions of a market, but irrespectively thereof (equations (β) and (γ), without equation (α) in note (*e*) above), the utilitarian arrangement, which also is represented by a point in the contract-curve, say u in fig. 9. Such might seem to be the ideally most desirable arrangement; but very likely the practically best, the πρακτὸν ἀγαθόν, is in the neighbourhood indicated by Professor Marshall and Messrs. Auspitz and Lieben.

(*m*) THE AUSTRIAN SCHOOL.—Professor Menger and his followers have expressed the leading propositions of the Economic Calculus—the law of diminishing utility, the law of demand and supply, and so forth—by means of particular numerical examples, supplemented with copious verbal explanation. Their success is such as to confirm the opinion that the mathematical method is neither quite indispensable nor wholly useless, *nec nihil nec omnia*, like most scientific appliances. Conceding that in the main they impart a saving knowledge of the true theory of value, it may still be maintained that they occasionally emphasise the accidents of a particular example as if they formed the essence of the general rule; that their explanations are excessively lengthy; and yet their meaning sometimes is obscure. For instance, Professor Böhm-Bawerk may seem to attach undue importance to his conception of the *Grenzpaar*. He illustrates the play of demand and supply by supposing a market in which on the one hand there are a number of dealers each with a horse to sell, and on the other

hand a number of would-be buyers (Konrad's 'Jahrbuch,' 1886; 'Kapital . . .,' p. 211. Cp. Mr. James Bonar's excellent article in the 'Quarterly Journal of Economics,' Oct. 1888). The latter are arranged in the order of their strength: first, the one who is prepared to give most for a horse, the highest price which the second can afford is less, and so on. Parallel to this arrangement is that of the would-be sellers: first, he who can sell cheapest; and so on. Upon this hypothesis it might happen that the fifth would-be buyer is willing to give a little more than the lowest figure which the fifth would-be seller will take; while the sixth on the side of the buyers is not willing to give quite as much as the sixth horse-dealer stands out for. In this case five horses only will be sold; and the couple who are the last between whom a bargain is possible —buyer No. 5 and seller No. 5—enjoy a mighty distinction as the *Grenzpaar*; an

FIG. 10.



honour which is to some extent shared with No. 6, the first couple between whom a bargain is impossible.

Now this attention to a particular couple is not always appropriate. How if the weakest actual buyer should prove to be, not buyer No. 5 but buyer No. 1, as to a *second* horse? Professor Böhm-Bawerk, indeed, has thought of this case, and called attention to it in a note to his later redaction ('Kapital . . .,' p. 218). So far—although the whole simplicity of the scheme is destroyed when we permit second and third horses to the different buyers and sellers —the conception of a 'limiting couple' may still be retained. It will be found, however, that this idea is not appropriate to the general case of a divisible commodity, which a single individual on one side of the market may buy from or sell to a large number on the other side. That general case is much more clearly represented by a diagram like fig. 10, where the inner thin-lined curves represent the dispositions of the individual dealer, the outer thick curves the collective supply and demand (cp. Auspitz and Lieben, 'Theorie der Preise'). No doubt Professor Böhm-Bawerk's conception is appropriate to a particular case, that in which the *Kleinste Marktübliche Mengeneinheit*, in the phrase of Messrs. Auspitz and Lieben (*Ibid.* p. 123), is considerable. But it is better with those eminent theorists to begin with the general or, at least, the simple case.

As an instance of the excessive circumlocution to which the purely literary method is liable, we may notice the doctrine of objective and subjective value, which occupies many pages in one of the works to which we have referred. Is there really much more in the distinction than what is visible on a glance at the appropriate diagram? The individual's subjective estimate of worth is expressed by his particular demand- or supply-curve Oe_1, Oe_2, &c., Og_1, Og_2, &c., in fig. 10. The proper combination of those individual curves gives the collective demand- and supply-curves, of which the intersection represents the 'objective' value.

Moreover, verbal circumlocutions are so little adapted to express mathematical conceptions that we are sometimes left in uncertainty as to our author's meaning. When Professor Böhm-Bawerk remarks that there is something special in the labour-market, in that the buyer will vary his arrangements according to the price of the article, the rate of interest ('Kapital,' p. 407), does he specify the property which Messrs. Auspitz and Lieben have stated as general; that the utility function (our ψ, note (e) above) is discontinuous, being different for large and small values of the variable under consideration?

These deficiencies are more conspicuous in other writings of the Austrian school. A glance at fig. 10, an intuition of the corresponding algebraic formulæ, will show that the notion of an *average* imported into the doctrine of value by Dr. Emil Sax (*Staatswirthschaft*) is not quite appropriate. As an instance in which great abridgment would be effected by mathematical expression, we might notice the last three chapters of Dr. Zuckerkandl's 'Theorie der Preise.' Again the difficulty of conveying technical propositions without the proper phraseology may be illustrated by Professor Wieser's 'Der natürliche Werth,' when he speaks of value and final utility having place in a Communistic or Socialistic State (p. 26 note and *passim*). May his meaning thus be formulated? In an economical *régime* distribution and exchange are regulated by the condition that the final utility of all concerned should be zero, the total utility a minimum, *subject to the law that there should be only one rate of exchange in a market.* In a communistic or utilitarian *régime* the limitation which the last italicised clause expresses is removed. In terms employed in our Note (e) the economical adjustment is determined by the equations (α), (β), and (γ); the utilitarian adjustment is determined by (β) and (γ) only—in short, the distinction between the points r and u in our fig. 9 referring to note (e).

In offering these trenchant criticisms I regret that my limits impose a curtness which is hardly consistent with courtesy.

The following Papers were read:—

1. *The Incidence and Effects of Import and Export Duties.* *By* C. F. Bastable.—See Reports, p. 440.

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2. *Index-numbers as applied to the Statistics of Imports and Exports.* *By* Stephen Bourne, *F.S.S.*

Two papers read at previous meetings of the British Association fully set forth a scheme for using index-numbers in ascertaining the relation of volume to value, and the comparison of these factors in the trade of the United Kingdom with her colonies and the ports of other nations. Both of these papers will be found published *in extenso* in the Report.[1] A more voluminous paper on the same subject will be published in the forthcoming number of the 'Roy. Stat. Soc. Journ.'[2]

It may be unnecessary, therefore, to say more on the present occasion than that the index-number adopted was 1,000 (convertible into 100, 10, or 1 by the use of the decimal points) to represent 240,000,000*l.*, which happened to be the value of the exports of British produce in the year 1883, when it was first em-

[1] Aberdeen, 1885, pp. 859–873; Bath, 1888, pp. 536–540.

[2] September, 1889, pp. 399–428.

ployed; and that the *value* of each specified article in the 'Trade Accounts' issued by the Board of Trade for the last eleven years, 1878–1888, has been converted into such an 'index.' That same index-number has, for the year 1883, which thus becomes the standard for comparison, been attached to the *quantity* of each article, whether of import or export. The average *price* of each article in 1883 being taken as 1·, the prices in subsequent years have been reduced to their proper equivalents. The index-number for the *value* has been divided by this equivalent, and the result taken to be the representative of the *volume*.

There is thus obtained an index-number having the fixed relation of 1,000 to 240,000,000*l.*, serving as an equivalent not only of the money values, but likewise of the several weights or measurements in which the accounts of the articles are registered. It thus becomes easy to see the relation between the volume and the values of each transaction for each year brought to the standard of 1883, and comparisons may be instituted between the individual and the total values of one year with all others for which the computation may be made. It should be mentioned that many of the goods in which we trade are not capable of estimation by either weight or measurement, and therefore are not represented in the 'Trade Accounts' in any terms but those of value; also, that a number of the least important of those which are so recorded in the Customs books are not named in the published accounts. In the absence, therefore, of any data on which to work, it has been assumed that the variations in price would be analogous to those of the specified articles, and the indices for volume have been in these papers computed at the corresponding ratios.

In the paper read at Aberdeen the several details for the British goods exported in 1884 were set forth in comparison with those in 1883. In that read at Bath the same comparison was instituted between 1887 and 1883. On the present occasion it is proposed to set forth in a similar manner the imports for 1888 in comparison with 1883, and, both imports and exports having been calculated for each year back to 1878, to quote some of these results as illustrative of the progress of our trade during those eleven years. One article—cotton wool—in which our trade is larger than any other, whether of import or export, may serve to explain the scope of the information the following table affords.

In 1883 the weight imported was 15,485,121 cwt.; in 1888, 15,462,099 cwt.; the values as declared by the importers being 45,042,296*l.* and 40,009,086*l.* —which gives the average price of 2·91*l.* for the one year and 2·58*l.* for the other, being in the ratio of 1· to ·89. From this it is evident that the lower price of 1888 would have procured a larger weight than in 1883. The index-numbers for the values being 187·7 and 166·6, we have but to divide the latter one by ·89 to get the volume which it represents, and find the index to be 187·2, or, rejecting the fraction, 187·, showing that the lower value of 1888 did not indicate a lesser volume of trade, which is verified by the figures of actual weight given. Adopting the same method with all other goods, we get index-numbers representing gallons, yards, &c., as well as cwts. These may be all added together, which the quantities could not. The result, as shown in the totals of the following table, is that, whereas our whole imports were valued in 1883 at 426,891,379*l.*, or in index-number 1,779, and in 1888 at only 387,635,743*l.*, the index-number for which is 1,615, or *less* by 9·2 per cent., the volume index-number is 1,948, or *more* by 9·5 per cent. We have thus gained in both ways, the saving in money paid and the enlargement of goods obtained—the double benefit being equal to nearly 20 per cent. in favour of the later year.

Calculating in the same way the exports of British goods, it will be found that those exported in 1883 were valued at 239,799,473*l.*, the index-number for which is 1,000; those in 1888, 233,842,607*l.*, or in index-number 974, being *less* by 2·6 per cent., whilst the volume index-number is 1,121, or 12·1 per cent. *more* than that for value. The reception of less money and, at the same time, the disposal of more goods is thus 15 per cent. to the disadvantage of 1888. It would appear, therefore, that the general lowering of prices has not affected the nation's trade adversely on our sales, to the same extent as it has acted beneficially on our purchases.

Foreign and Colonial Goods imported in 1888, *compared with those of* 1883.

Articles		1883			1888				
		Aver. Price	Value of Imports		Aver. Price	Value of Imports	Index-numbers		
			In million £'s	Index No.			Value	Price	Volume
Animals—						£			
Oxen . .	each	21·57*l.*	7·93	33·0	17·86*l.*	5·13	21·4	·83	26
Cows . .	„	—	1·18	4·9	12·77*l.*	·63	2·7	—	3
Calves. .	„	4·67*l.*	·22	·9	3·64*l.*	·15	·6	·78	1
Sheep and lambs	„	45·13*s.*	2·52	10·5	36·41*s.*	1·74	7·3	·81	9
Bacon . .	cwt.	53·08*s.*	8·18	34·2	44·78*s.*	6·41	26·7	·84	32
Hams . .	„	60·55*s.*	1·86	7·7	52·83*s.*	1·93	8·0	·87	9
Beef . .	„	52·91*s.*	2·89	12·1	42·67*s.*	2·27	9·5	·81	12
Bones . .	ton	7·15*l.*	·62	2·6	5·15*l.*	·39	1·6	·72	2
Brimstone .	cwt.	5·52*s.*	·24	1·0	4·48*s.*	·17	·7	·81	1
Bristles . .	lb.	39·92*d.*	·45	1·9	32·42*d.*	·38	1·6	·81	2
Butter and Margarine	cwt.	5·04*l.*	11·77	49·1	5·33*l.* 2·87*l.*	12·18	37·2 13·6	·86	43 16
Candles .	doz. lbs.	67·94*d.*	·19	·8	50·57*d.*	·14	·6	·74	1
Caoutchouc .	cwt.	15·94*l.*	3·66	15·2	11·60*l.*	2·56	10·6	·73	15
Cheese . .	„	2·72*l.*	4·89	20·4	2·37*l.*	4·55	19·0	·87	22
Chinaware .	„	—	·60	2·5	—	·60	2·5	—	4
Clocks . .	each	13·01*s.*	·47	2·0	—	·47	2·0	·70	3
Cocoa . .	lb.	7·97*d.*	·75	3·1	7·53*d.*	·93	3·9	·94	4
Coffee . .	cwt.	3·51*l.*	4·94	20·6	3·77*l.*	3·58	14·9	1·07	14
Confectionery	„	2·75*l.*	·74	3·1	2·28*l.*	·04	·2	·83	—
Corn, wheat .	„	9·81*s.*	31·45	131·1	7·68*s.*	22·00	91·6	·78	117
„ barley .	„	6·98*s.*	5·74	23·9	5·70*s.*	6·07	25·3	·82	31
„ oats .	„	6·62*s.*	5·01	20·8	4·90*s.*	4·60	19·1	·74	26
„ maize .	„	6·53*s.*	10·37	43·2	5·43*s.*	6·89	28·7	·83	35
„ O. kinds.	„	7·68*s.*	2·21	9·2	5·76*s.*	1·97	8·9	·75	11
„ wheat-flour	„	15·12*s.*	12·34	51·4	11·27*s.*	9·53	39·7	·75	53
„ O. kinds flour	„	8·15*s.*	·49	2·1	5·75*s.*	·19	·8	·71	1
Cotton, raw .	„	2·91*l.*	45·04	187·7	2·58*l.*	40·01	166·6	·89	187
Drugs—									
Bark, Peruvian	„	12·17*l.*	1·42	5·9	3·81*l.*	·55	2·3	·31	8
Opium .	lb.	14·56*s.*	·56	2·4	12·45*s.*	·37	1·5	·86	2
Dyestuffs—									
Cochineal, &c.	cwt.	7·15*l.*	·15	0·6	6·55*l.*	·05	·2	·92	—
Cutch, &c. .	ton	26·48*l.*	·71	3·0	24·73*l.*	·71	2·9	·93	3
Indigo .	cwt.	24·50*l.*	2·46	10·2	21·79*l.*	1·70	7·1	·89	8
Shumach .	ton	14·47*l.*	·22	·9	11·24*l.*	·14	·6	·78	1
Valonia .	„	15·89*l.*	·48	2·0	14·28*l.*	·46	1·9	·90	2
Unrated .	cwt.	—	·85	3·6	—	·80	3·3	·90	4
Dyewoods .	ton	5·91*l.*	·52	2·2	5.74*l.*	·46	1·9	·97	2
Eggs . .	doz.	8·37*d.*	2·73	11·4	7·88*d.*	3·08	12·8	·94	14
Feathers, ornamental	lb.	62·27*s.*	2·01	8·4	24·92*s.*	·82	3·4	·40	9
Fish . .	cwt.	35·53*s.*	2·30	9·6	24·37*s.*	2·32	9·7	·69	13
Flax . .	„	39·92*s.*	2·52	10·5	33·98*s.*	3·00	12·5	·78	16
Tow . .	„	24·02*s.*	·47	2·0	22·86*s.*			·95	
Hemp . .	„	33·48*s.*	2·39	9·9	30·96*s.*	2·80	11·7	·92	12
Jute . .	„	12·26*s.*	4·53	18·9	12·44*s.*	3·90	16·3	1·01	16

Foreign and Colonial Goods imported in 1888, *compared with those of* 1883—cont.

Articles	1883			1888				
	Aver. Price	Value of Imports: In million £'s	Value of Imports: Index No.	Aver. Price	Value of Imports	Index-numbers: Value	Index-numbers: Price	Index-numbers: Volume
					£			
Fruit, currants cwt.	27·72*s.*	1·42	5·9	26·57*s.*	1·34	5·6	·96	6
„ raisins . „	35·97*s.*	1·06	4·4	30·34*s.*	·92	3·8	·84	4
„ oranges bush.	7·62*s.*	1·70	7·1	6·01*s.*	1·46	6·1	·79	7
„ raw . „	—	1·93	8·1	—	2·43	10·1	·79	13
Glass—								
Window . cwt.	15·69*s.*	·54	2·2	12·04*s.*	·50	2·1	·77	3
Flint . „	—	·18	·8	—	·20	·8	·77	1
Manufactures of „	—	·89	3·7	—	1·20	5·0	·77	7
Guano . . ton	9·76*l.*	·72	3·0	8·04*l.*	·20	·8	·82	1
Gutta-percha . cwt.	7·47*l.*	·48	2·0	8·08*l.*	·18	·8	1·08	4
Gum of all sorts „	—	1·23	5·1	—	1·14	4·3	—	1
Hair, goat's . lb.	18·89*d.*	1·05	4·4	10·22*d.*	·94	3·8	·54	7
Hides, raw . cwt.	3·18*l.*	3·80	15·9	2·58*l.*	3·00	12·5	·81	15
Hops . . „	8·39*l.*	1·09	4·5	3·70*l.*	·80	3·3	·44	8
Lard . . „	52·65*s.*	2·25	9·4	41·11*s.*	1·82	7·6	·78	10
Leather . . lb.	17·56*d.*	5·47	22·8	15·51*d.*	5·96	24·6	·88	29
„ gloves pair	23·25*d.*	1·94	8·1	21·74*d.*	1·60	6·7	·94	7
Meat—								
Salted or fresh cwt.	2·96*l.*	·81	3·4	1·97*l.*	2·06	8·6	·67	13
Preserved . „	2·87*l.*	1·75	7·3	2·54*l.*	1·38	5·7	·89	7
Metals—								
Copper ore . ton	10·34*l.*	1·10	4·6	8·64*l.*	1·10	4·6	·84	5
„ regulus „	31·83*l.*	1·84	7·7	37·49*l.*	3·88	16·2	1·18	14
Copper unwrought „	65·04*l.*	2·41	10·1	78·40*l.*	8·61	15·0	1·23	13
Iron ore . „	17·24*s.*	2·75	11·4	13·86*s.*	2·47	10·3	·80	13
„ bars . „	10·06*l.*	1·24	5·2	9·06*l.*	1·03	4·3	·90	5
„ manufactures cwt.	14·80*s.*	2·87	12·0	14·65*s.*	2·31	9·6	·99	10
Lead, pig . ton	12·83*l.*	1·31	5·4	13·92*l.*	1·85	7·7	1·08	7
Tin . . cwt.	4·69*l.*	2·44	10·2	6·28*l.*	3·52	14·7	1·34	20
Zinc, crude . ton	15·70*l.*	·64	2·7	17·43*l.*	1·05	4·4	1·11	2
„ manufactures cwt.	1·00*l.*	·41	1·7	1·01*l.*	·37	1·5	1·01	1
Nuts for oil . ton	14·24*l.*	·87	3·6	11·33*l.*	·72	3·0	·79	4
Oil, fish . . tun	35·25*l.*	·60	2·5	19·19*l.*	·32	1·3	·54	3
„ palm . cwt.	35·11*s.*	1·32	5·5	19·83*s.*	·95	4·0	·56	8
„ cocoanut . „	34·69*s.*	·37	1·5	25·34*s.*	·25	1·0	·73	1
„ olive . tun	38·61*l.*	1·20	5·0	36·29*l.*	·67	2·8	·94	3
„ seed . . „	34·82*l.*	·37	1·5	25·37*l.*	·41	1·7	·73	2
„ turpentine cwt.	31·75*s.*	·56	2·3	28·85*s.*	·52	2·2	·91	2
Oilseed cake . ton	7·55*l.*	1·94	8·1	6·24*l.*	1·61	6·8	·83	8
Onions, raw . bshl.	3·28*s.*	·44	1·8	3·68*s.*	·64	2·7	1·12	2
Paper, writing, &c. cwt.	33·02*s.*	·34	1·4	28·09*s.*	·48	2·0	85	2
Paper, O.S. . „	—	·90	3·8	—	1·29	5·4	·85	6
Petroleum . gall.	7·39*d.*	2·17	9·0	6·52*d.*	2·57	10·7	·88	12
Pork . . cwt.	40·43*s.*	·76	3·2	37·61*s.*	·92	3·8	·93	4
Potatoes . . „	6·16*s.*	1·59	6·6	6·73*s.*	·80	3·3	1·09	3

Foreign and Colonial Goods imported in 1888, *compared with those of* 1883—cont.

Articles		1883 Aver. Price	1883 Value of Imports: In million £'s	1883 Value of Imports: Index No.	1888 Aver. Price	1888 Value of Imports £	Index-numbers: Value	Index-numbers: Price	Index-numbers: Volume
Pyrites . .	ton	45·11*s.*	1·36	5·7	38·11*s.*	1·18	4·9	·84	6
Rags . . .	„	14·08*l.*	·40	1·7	11·37*l.*	·47	2·0	·81	2
Esparto . .	„	6·74*l.*	1·94	8·0	5·42*l.*	2·32	9·6	·80	12
Rice . .	cwt.	8·20*s.*	3·18	13·2	7·46*s.*	2·31	9·6	·91	11
Rosin . . .	„	5·82*s.*	·40	1·7	4·10*s.*	·27	1·1	·70	2
Saltpetre .	„	20·04*s.*	·29	1·2	17·02*s.*	·30	1·3	·85	1
Cubic nitre .	„	11·41*s.*	1·17	4·9	9·59*s.*	·98	4·1	·84	5
Seeds, clover .	„	47·59*s.*	·75	3·1	41·26*s.*	·68	2·9	·87	3
„ cotton .	ton	7·40*l.*	1·84	7·7	6·44*l.*	1·65	6·9	·87	8
„ flax .	qr.	2·06*l.*	4·79	20·0	1·89*l.*	4·79	20·0	·92	22
„ rape .	„	2·15*l.*	1·65	7·0	1·61*l.*	·45	1·9	·75	3
Silk, knubs .	cwt.	14·50*l.*	·90	3·8	11·83*l.*	·99	4·1	·82	5
„ raw .	lb.	16·20*s.*	2·58	10·7	12·29*s.*	1·88	7·8	·76	10
„ thrown .	„	1·04*l.*	·30	1·3	·83*l.*	·46	1·9	·80	2
Skins, sheep .	each	29·57*d.*	1·00	4·2	26·54*d.*	·99	4·1	·90	5
„ seal .	„	13·20*s.*	·44	1·9	16·24*s.*	·58	2·4	1·23	2
„ goat .	„	22·89*d.*	·45	1·9	26·57*d.*	·58	2·4	1·16	2
„ furs .	„	—	·94	3·9	—	·75	3·1	—	3
Spices, cinnamon	lb.	13·61*d.*	·10	·4	7·61*d.*	·04	·2	·56	—
Spices, pepper	„	6·42*d.*	·84	3·5	7·68*d.*	·92	3·8	1·20	3
„ O.S. .	„	6·37*d.*	·60	2·5	5·28*d.*	·60	2·5	·83	3
Spirits, rum	pf. gal.	1·86*s.*	·56	2·3	1·64*s.*	·34	1·4	·88	2
„ brandy	„	9·18*s.*	1·01	4·2	9·19*s.*	1·22	5·1	1·00	6
„ O.S. .	„	4·19*s.*	·35	1·5	2·42*s.*	·21	·9	·58	1
Sugar, refined .	cwt.	27·22*s.*	4·47	18·6	17·54*s.*	6·04	25·1	·64	39
„ raw .	„	20·10*s.*	20·47	85·3	13·57*s.*	12·11	50·4	·68	76
„ molasses	„	8·34*s.*	·16	·7	6·32*s.*	·11	·5	·76	1
Tallow . .	„	40·48*s.*	2·10	8·8	25·00*s.*	1·43	6·0	·62	10
Tea. . . .	lb.	12·46*d.*	11·54	48·1	10·99*d.*	10 20	42·5	·88	48
Teeth, elephants'	cwt.	46·95*l.*	·64	2·7	45·70*l.*	·54	2·2	·97	2
Tobacco, cigars	lb.	12·41*s.*	1·07	4·4	9·76*s.*	1·32	5·5	·79	6
„ cavendish	„	11·50*d.*			11·18*d.*			·97	
Tobacco, unmanufactured.	„	7·63*d.*	1·79	7·5	7·53*d.*	1·46	6·0	·99	6
Wine . .	gall.	7·01*s.*	5·45	22·7	7·31*s.*	5·39	22·4	1·04	22
Wood, hewn .	load	2·61*l.*	5·62	23·4	2·04*l.*	4·06	16·7	·78	22
„ sawn .	„	2·41*l.*	10·41	43·4	2·22*l.*	9·67	40·3	·92	44
„ staves .	„	4·53*l.*	·64	2·7	4·10*l.*	·59	2·5	·91	3
„ mahogany	ton.	9·85*l.*	·49	2·1	8·80*l.*	·37	1·5	·89	2
Wool . .	lb.	12·08*d.*	24·95	104·0	9·78*d.*	25·93	108·0	·81	133
Woollen—									
Rags . .	ton	21·17*l.*	·76	3·2	20·80*l.*	·66	2·7	·98	3
Yarn, fancy	lb.	43·04*d.*	·17	·7	42·10*d.*	·21	·9	·98	1
„ weaving	„	30·18*d.*	1·83	7·6	27·13*d.*	1·86	7·8	·90	9
Yeast . .	cwt.	2·80*l.*	·73	3·1	2·73*l.*	·73	3·1	·97	3
All other articles .		—	55·94	232·7	—	62·87	262·0	—	316
		—	426·89	1779·4	—	387·64	1615·2	—	1,948

These remarks have reference to the fifth year succeeding 1883. If the calculations be carried back for five years preceding the one which happens to have been taken as the standard one, because it was the latest available for the Aberdeen meeting, we get the full period of eleven years, which is by some supposed to be a cycle in commercial history. The following table ranges side by side the several index-numbers for each year of both imports and exports, and in each of these for volume as well as value. Interposed between them are the value indices for the goods which, having been imported, were again sent away. These might have been either deducted from the imports or added to the exports, for they belong to the one as well as to the other, but the classification of the several articles adopted in the Official Trade Returns, from which the figures are derived, is not amenable to this treatment, and therefore the value index can alone be given. This, however, will serve to represent in value the relative extent of the re-export trade, and that of its volume would probably incline more towards that of the imports than to that of the British exports. By a deduction from the imports the value of those which are retained for home consumption or manufacture may be obtained.

Table of Index-numbers, of both Value and Volume, for each year 1878–1888, *inclusive,* 1,000 *being equivalent to* 240,000,000*l.*

Year	Colonial and Foreign Goods Imported		Re-exported	British Goods Exported	
	Value	Volume	Value only	Value	Volume
1878	1·537	1·492	219	803	757
1879	1·512	1·528	238	798	794
1880	1·713	1·659	264	929	888
1881	1·654	1·611	263	975	973
1882	1·721	1·650	272	1,006	989
5 years	*8·137*	*7·940*	*1,256*	*4,511*	*4,401*
1883	1·779	1·779	274	1,000	1,000
1884	1·625	1·712	262	971	1,000
1885	1·546	1·769	243	888	957
1886	1·458	1·770	234	885	1,014
1887	1·510	1·798	248	922	1,064
1888	1·615	1·948	268	974	1,121
5 years	*7·754*	*8·997*	*1,255*	*4,640*	*5,156*
11 years	17·670	18·716	2·785	10·151	10·557

It will be noticed that for the first period of five years the volume fell short of the value as compared with 1883, and that in the later period the volume exceeded the value. The year 1883 thus marks a transition point when prices generally began to decline.

It is this power which the index-figures confer of comparing one period with another, and the one side of our trade, its incomings with its outgoings, which seems to render a simple and uniform system of some value. When reduced to a visible expression, as in the diagram attached to the Statistical Society's paper, a glance suffices to show, not only the differences between the values of the imports and the exports, but their respective bulks as well. There is then prominently brought to view the fact of our exports moving progressively, increased in volume more than in value up to the present time. Consequently, with this the imports must likewise grow in bulk in a still greater proportion.

FRIDAY, SEPTEMBER 13.

The following Papers were read:—

1. *The Comtist Criticism of Economic Science.*
By W. CUNNINGHAM, *D.D.*, *D.Sc.*—See Reports, p. 462.

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2. *On the Present State and Future Prospects of our Coal-supply.*
By Professor EDWARD HULL, *LL.D.*, *F.R.S.*

The author regarded the meeting at Newcastle as a fitting opportunity for reviewing the prospects of our coal-supply—as this question formed the principal subject of the address of Lord Armstrong at the last meeting of the Association at Newcastle in 1863; and since that time the output of coal from British mines had been proceeding with accelerated rapidity, though subject to periodical fluctuations. A diagram had been prepared and was exhibited to show by a series of co-ordinates the rate of production from the commencement of the century. At this date the output of coal probably did not exceed 10,000,000 tons, a very large proportion of which was drawn from the Newcastle district. In the year 1830 the quantity raised in the British Islands was about 29,000,000 tons; in 1860 it had reached 80,042,698; and in 1888 the quantity had reached about 170,000,000 tons, as shown by the returns issued by the Board of Trade. There was reason for believing that between the beginning of the century and the year 1875 the output of coal had more than doubled itself for each successive quarter of a century. Since the year 1860, in which the author had estimated that sufficient coal existed to a limiting depth of 4,000 feet to last, at *the rate of production for that year*, for one thousand years, the available quantity of coal had been reduced by 3,650,000,000 tons; but this amount, great as it was, had not very materially affected the actual quantity of coal in the British islands, though it had made a very appreciable inroad on the supposed available resources.

The relation between coal-production and the development of the iron-trade since the discovery of the iron-stone deposits of the North Riding of Yorkshire, and the richer hæmatites of North Lancashire and Cumberland, was then considered; and the different coal-fields of the British Isles were passed in review in order to show those which are in a progressive condition and those which are stationary or retrogressive. The author concluded his subject by expressing an opinion that, while the enormous output of coal during the past few years had not actually crippled our resources, a general rise in the value of coal must ensue in the near future, owing to the greater depth at which the mines will have to be worked, and the increased cost of coal-mining Reference was then made to the great expansion of coal-mining in America, as illustrated diagrammatically, and the author agreed with the late Professor Jevons that future British manufacturers must not expect to derive any help from the import of coal from the United States when coal shall have become dear or scarce at home.

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3. *Our West African Possessions: their Economic Opportunities and how they are abused and neglected.* *By* H. R. FOX BOURNE.

Our West African possessions are not properly colonies. Though we have acquired considerable territory and extensive sea-frontage at the Gambia, Sierra Leone, the Gold Coast, Lagos, and the Niger Protectorate, these places are not adapted for European settlement, and almost their only political value to us is in connection with commerce. We should so hold them, if we choose to hold them at all, as to develop honourable trade with the natives near the coast and also with the superior and far more numerous races that inhabit the tablelands in the interior, where a genial climate, an immense area of fertile soil, and a profusion of

mineral wealth, afford facilities for a vast development of commerce, which should be beneficial alike to the natives and to the Europeans who deal with them.

The tendency of our present policy is to leave this work to be done, if at all, by the French, who, in extending their influence along the course of the Senegal and among the communities beyond, are acquiring a position which may prove extremely detrimental to us in our dealings with the tribes near the coast. In the meanwhile, by our treatment of these latter tribes, we are doing yet more to injure our prospects and spoil our opportunities. Such harsh and frivolous meddling with the natives as is generally the rule with our officials on the West African coast, though ostensibly and primarily adopted with a view to protecting and extending our trade, is really most prejudicial to it.

As quite recent examples of this mischievous and discreditable policy, may be adduced the expedition despatched from Sierra Leone this year against the Chief Markiah in the Sulymah district, last year's crusade against the Tavieves at the Gold Coast, and the recent overthrow and deportation of King Ja Ja in the Niger Protectorate.

Our policy should be to befriend, not to bully, the natives; to make alliances with their chiefs, not wars against them. As Lord Brassey has said, 'We must co-operate with the native populations in the development of their resources, we must help them to accumulate wealth or they cannot purchase our goods.'

SATURDAY, SEPTEMBER 14.

The following Papers were read:—

1. *Agricultural Statistics. By* WM. BOTLY, *M.R.A.S.E.*

The paper gave a tabular statement of the acreage of corn, green, and grass crops; number of horses, cattle, sheep, and swine; value of corn, food, and live stock imported; of dead meat in cwts.; and value in 1887 and 1888. Number and value of horses imported and exported as decidedly in favour of our own breed of horses in number and value. The import of wool, butter, cheese, eggs, &c.

The comparative yield of wheat, &c., in different countries, proving the great superiority in our yield per acre. Rental, expenses, and profit per acre, with total production and value of all crops; comparative acreage of tilled and untilled land in this and other countries, Russia having the smallest and Denmark the largest proportion under cultivation, and the United Kingdom only 29 per cent. tilled as against 71 untilled of its acreage.

The value of imported agricultural produce was shown to be 3*l.* 5*s.* to each inhabitant; the results of fruit-farming; and that agriculture, though the largest single interest, was only 14 per cent. of all the other industries.

The author considered that banking on sound principles had been a great assistance to agriculturists, especially in the trying seasons we had passed through, and which may not as yet have cleared off; by the way instancing the great development of our colonies through banks and other cognate establishments; concluding by showing the utility and antiquity of agricultural statistics in the prevention of famine by quoting the 41st chapter of Genesis.

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2. *On the Methods of Forecasting the Yield of Crops. By* Professor W. FREAM, *LL.D., B.Sc., F.S.S.*

It has become a custom in this country to make, in the early part of August, a forecast of the yield of crops—that is, an estimate as to the probable produce of the chief cultivated crops. The method adopted is to send out printed forms, or schedules, to a large number of farmers in all parts of the country, with the request that they should be returned, duly filled up, by a certain specified date. Two

modes of estimation are in use. Under the one system, the correspondent states whether, according to his observations in the field, each crop is 'over-average,' 'average,' or 'under-average.' The returns are tabulated, and a general verdict for the whole country is arrived at according to whichever of the three heads just specified secures the largest percentage of adherents. The error of this system lies in its utter vagueness, inasmuch as all over-average estimates are treated as equal amongst themselves, whilst the under-average estimates are similarly all regarded as equivalent to each other. Moreover, it is inevitable that one over-average and one under-average estimate must be regarded as equivalent to two average estimates, and, therefore, counteract each other, no graduation of over-average or of under-average estimates being attempted. The other system is free from these errors. Its essential feature involves the taking of the number 100 to represent an average crop, and increasing or diminishing this according as the crop is above or below average. Thus, 90 would indicate a crop estimated to give 10 per cent. below an average yield, and 75 would denote a crop anticipated to fall one-fourth below the usual yield. On the other hand, 150 would indicate a yield half as large again as the average. This method, being more exact, is decidedly preferable, particularly for the establishment of general numerical results applicable to the whole country.

But both systems are open to serious objection, in that they take no account of area. Adopting the numerical system of estimate, it is suggested that every number indicating the current valuation of the yield of a crop should be associated with the area, expressed in acres, to which the estimate applies. Thus, an estimate of 105 and one of 95 would, at present, be considered equivalent to two estimates of 100, whereas one of the estimates might apply to hundreds of acres, and the other only to a score or so. In each case the area in acres and the numerical estimate should be regarded as factors, and the sum of all the resulting products divided by the total number of acres would give a more reliable general forecast of the probable yield per acre than has yet been obtained. In mathematical language, the general forecast should be a function both of the numerical estimates of the yield and of the area involved. The subject is of considerable commercial importance, as market quotations are influenced by these forecasts.

Figures and illustrations were given in support of the paper.

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3. *Improved Dwellings for the Poor.* By D. G. Hoey.

It is manifest that, although the greatest improvements in vital conditions were made by the cultured and intelligent, this would only serve to make still wider the already wide gulf existing between the conditions of life and the death-rate of those in comfort and those in poverty; and in order to any marked effect being produced on the general tables of mortality, the improved practice and improved conditions must be brought down to and participated in by the masses; hence the clamant importance of the question of questions in economic science—improved dwellings for the poor.

The subject is a vast one, requiring great detail for its expansive treatment, but this I reserve for a future paper, and limit myself to indicating, in broad lines (1) the extent, depth, and urgency of the evils, and (2) the method proposed for their cure.

I. Any large city will suit for illustration. Take, first, Glasgow, of which I know most. One-fourth of the inhabitants live in single apartments, nearly 70 per cent. in houses of one and two apartments, often with lodgers. The death-rate in such one- and two-roomed houses is 27·74 per thousand; in three- and four-roomed houses, 19·45; in houses of five rooms and upwards, 11·23.

The great majority of the two-roomed houses, and a number of the single apartments, are occupied by superior skilled workmen and others of a superior class, whose mortality is much lower, and the high figure is made up by a comparatively small proportion, in which the rate is enormously high. In one district, comprising houses of all the classes, it is 42 per 1,000; what must it be in the worst class

there? My subject is dwellings for the poor, not for superior skilled artisans, and in most parts of Glasgow, where the poorer classes dwell, a healthy and well-trained family is not a possible thing. The rent paid for single-apartment houses is from 4*l.* to 5*l.*, and some 5*l.* 12*s.* a year. Nothing but proper accommodation at similar rents, so paid for hovels, will meet the case or materially lessen the great mortality.

I next take London. The best done there for the poor is as follows:—A single apartment, bare walls, 10 ft. by 7 ft., accommodating one person, quite unventilated, 3*l.* 18*s.*, fifth floor; 5*l.* 12*s.* lower down; others, 15 ft. by 12 ft., same discomfort, in which a couple and some children may huddle, 7*l.* 3*s.* at the high, and 9*l.* 2*s.* at the low level. These are the best examples producible of 'model dwellings' of a benevolent association!! Anything more wretched for model dwellings cannot be imagined.

In the matter of proper house accommodation, when we come to the abodes of unskilled labourers in all large cities, the relation between supply and demand fails. The enterprise of providing improved houses for the poor is a virgin field, in which never a furrow has yet been turned.

II. The method of cure proposed. The chief points of difficulty are—

(1) The cost of ground, rendering it inevitable that many such houses should be erected in a limited space.
(2) Providing means, within such space, for due separation and privacy of the sexes, together with
(3) Thorough ventilation, producing continuous renewal of the atmosphere, whilst
(4) Causing no discomfort or danger by draughts.
(5) Comfortable warmth; protection from cold in winter.
(6) Adequate privy accommodation, accessible to women and children.

A seventh—adequate cubic space—has received great prominence, and legal enactment has prescribed a minimum of 300 cubic feet per adult; but this measure of adequacy is a dangerous delusion; the true measure of adequacy is the degree of continuous renewal of the atmosphere, and that is wholly wanting in the existing houses. The system of ventilation already described [1] can be efficiently adapted, in its essentials, to such houses, adding little or nothing to the cost of erection, and I am prepared to take what cubic space can be got, facing the inevitable.

The first difficulty—cost of ground—is thus removed, so far as mechanical science is concerned, whilst the third and fourth—renewal of the atmosphere without draught—have been disposed of; the fifth—comfort and protection from cold—is secured by a variety of simple devices, such as air spaces in the walls, and entrances from closed and ventilated passages; and the sixth—adequate privy accommodation—is fully met in the plans. The second—due separation and privacy for the sexes, within limited space—is so important as to call here for a little detail.

The plans proceed on the principle of the state cabin on board ship. Given a bare room, 15 ft. by 11 ft. by 13 ft. high, the door 2 ft. 6 in. in middle of 11 ft. end, leaves 4 ft. 3 in. on each side, enclosed by a partition 6 ft. from the door, forming two bed-closets or cabins, 6 ft. by 4 ft. 3 in. by 7 ft. high. The partition is carried up to the ceiling, enclosing another bedchamber, 11 ft. by 6 ft. by 6 ft. high.

The cabins are each fitted with two berths, 6 ft. by 21 in., leaving floor space 6 ft. by 2 ft. 6 in., furnished with lockers and seat and cupboard. The bedchamber above has a bed 6 ft. by 4 ft. and floor spaces 6 ft. by 5 ft. and 6 ft. by 2 ft., with 11 ft. range of lockers and a large cupboard. The space left for the family room is 11 ft. by 9 ft. and 13 ft. high.

There are numerous other provisions for convenience and comfort, including a cheap economical stove, that burns any slack to white powder, does the cooking, the warming, and the ventilating all at once; and every other provision has been

[1] In my paper on 'The Science of Ventilation as applied to the Interior of Buildings,' *Journal of the Society of Arts*, May 31, 1889.

made, down to the minutest particular, for economising space and cost of erection and of working. The stove has been tested and proved capable of giving a renewal of the atmosphere *every hour*, twice the 300 cubic feet supposed to be sufficient for a whole night; so that, whilst, without such arrangements, the adequate space of the statute is a delusion and a snare, with them, any space, legally adequate or not, may be kept at all times, and without intermission, in atmospheric purity and comfort.

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4. *The Increase in Europe and America of Nominal or Fictitious Capital. By* HYDE CLARKE, *F.S.S.*

The writer referred to the history of the joint stock system in the United States, France, and England, under which fictitious values in shares or stocks were created for goodwill or other matters, which did not represent real or effective capital. Of late years these sums had reached very large amounts, and, being treated by statists, economists, and journalists as real amounts, led to erroneous conclusions. Thus, in England, month after month large columns of figures were given adding up the capitals of projected companies, which, if they represented real sums would suggest the danger of a panic time after time. No such panics occurred, because these amounts were chiefly transfers of nominal sums from one individual to another in the purchase or sale of breweries, gold and other mines, patents, mercantile businesses, &c. In many cases such companies were mere family arrangements to avoid the mercantile risks of individual liability, and where no real change of condition or constitution of effective capital occurred. These operations, carried on by promoters and adventurers, had reached such an extent that they demanded the careful consideration of economists. In a time of panic, although no real destruction of the national capital may take place, the suffering to individuals from fluctuation of price will be very great. Even where a profitable business is carried on, great depreciation of the market price of shares and debentures will take place. At the present time the rate of investment is little above three per cent.; and a brewery returning 100,000*l.* per annum would be marketable on the scale of the rate of interest on investments advancing to five per cent., but there would be a great change and large depreciation. Still more would this be the case when, as in recent panics, six or seven per cent. was required as a return on investments.

MONDAY, SEPTEMBER 16.

The following Papers were read:—

1. *The Relations between Industrial Conciliation and Social Reform. By* L. L. PRICE, *M.A.*

The paper was devoted to some general considerations on the character of the relations existing between the various methods of securing the peaceful settlement of industrial disputes known as (1) arbitration, (2) conciliation, and (3) the sliding scale, and general social reform. The study of social and industrial questions leads to the conclusion that social and industrial reform is dependent on moral reform. But this is often forgotten, and more importance attached to the 'machinery' of reform than to the 'material' of human nature with which reform has to deal. The neglect of the fact that human nature changes slowly, bit by bit, leads to extravagant optimism and excessive pessimism with regard to the methods of securing the peaceful settlement of industrial disputes. We must expect that this 'machinery' will sometimes fail, but this expectation has its compensations as well as its drawbacks. A change has taken place in the 'material,' and theory and practice testify to an improvement in human nature as between masters and men. This is specially illustrated by the position of trades-unions in

general opinion and conversation, and also in economic literature. The practical consequences of this are important, for thus alone can effective representation of the men be secured; but the lessons of the recent history of the Northumberland coal trade must not be ignored. Although the 'machinery' of industrial peace is not everything, yet it is something, and it may modify the 'material' of human nature, and should therefore be brought to as great perfection as is possible. The most desirable quality is adjustability, and this may be understood in different senses: (1) adjustability to the varying circumstances of trade, (2) to the varied circumstances of each particular industry, (3) to those which vary from one industry to another, and (4) to the varying stages of improvement in the relations between masters and men. Future, like past and present, industrial society will probably present manifold diversities, and the ideal attitude of the social reformer should be catholic and critical.

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2. *The Difficulties of Arbitration.* *By* ROBERT SPENCE WATSON, *LL.D.*

Industrial war is in the air: it is the time to consider what difficulties prevent the peaceable settlement of labour disputes, and how to overcome them.

There are only two instances in which a peaceable settlement is impossible excepting by the submission of one side—when, in a wages dispute, a rise would mean bankruptcy to the employer; a fall, starvation to the employed.

Here for many years past, in several of the most important industries, the way to avoid war has been found and followed with great success, and without appeal to law. There have been interruptions, but they are accounted for, and a great balance of advantage remains to the credit of the peaceful system. The number of disputes settled and arranged by joint boards of conciliation and arbitration in the coal and iron industries was here stated.

Habitual peace has been tried in many industries of widely differing character, and in many parts of the country. Why is it not generally adopted?

The first reason is caste feeling upon both sides—want of mutual trust, neither party believing it possible to convince the other. This makes employers unwilling to recognise unions amongst the men, without which joint boards are scarcely possible, for they must represent practically the whole of a given trade in a given district. Again, employers dislike the idea of furnishing information about their own business transactions to others.

These objections vanish with experience of the actual working of joint boards which promote mutual good feeling and sympathy, and tend to lessen caste feeling.

The best way to ensure the peaceable solution of labour disputes is to promote the formation of joint boards of conciliation and arbitration in all branches of industry, and, that they may have the best chance of success, to encourage combinations of employers and employed.

But how far is this system applicable to unskilled labour, meaning thereby labour which has nothing to learn, but can be transferred from one place or trade to another without difficulty.

There is little accurate knowledge of the number of skilled and unskilled workmen in the Tyneside district. Certain works furnished exact figures which were given, but only very general conclusions could be come to. The amount of unskilled labour to be considered is very great. The difficulties of the problem are intensified in the metropolis, but do not differ in kind from those in the provinces. The remedy is to be found in systematic organisation, leading to the establishment of a method of peaceable settlement similar to that which works successfully in so many cases of skilled labour.

The difficulties in the way of successful organisation occasioned by the uncertainty, the nomadic character, the poverty, ignorance, and necessary unthriftiness, of unskilled labour were considered. A comparison between the condition of the skilled labourer fifty years since and at the present time was drawn, and hope for the future of unskilled labour derived from it.

But what is the chance of the systematic organisation of unskilled labour, and

of that organisation, if attained, being used for the peaceful settlement of labour disputes?

The present important movements in unskilled labour tend towards organisation. The ruling demand is for greater certainty of employment. The movements are partly due to the spread of education. With experience, employment, and education, organisation must become easier.

With good organisation the possibility of peace is increased. The unskilled labour employed in industries which have joint boards will be attended to by them. The overplus is divided amongst many different kinds of employment. But the relationship of employers to unskilled labour is probably the same whatever the trade. It might be classified under certain heads, each of which might have its joint board. There is theoretically no difficulty in the unskilled labour of each trade in each town or district having its own joint board, but practically only that employed in industries which had no joint board for skilled labour, or in which only unskilled labour was employed, would need to combine and have a board of its own.

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3. *On the Relation between Wages and the Remainder of the Economic Product. By* SIDNEY WEBB, *LL.B.*

1. *The Problem one of Classification not of Distribution.*—The scientific determination of the various divisions of the wealth product is primarily a problem, not of distribution, as it has usually been treated, but of classification. The economic product, obviously heterogeneous in its non-economic attributes, is economically homogeneous only in its attribute of valuableness. This aggregate wealth product is open, quite irrespective of its objective distribution, to scientific analysis and classification, based upon essential differences of economic attributes. The actual or potential objective distribution of the product among consumers, the outcome of all the circumstances—historic, industrial, and ethical—of each community, is largely effected by this natural classification, but never wholly coincides with it. In economic wealth classification wage has no more to do with the hiring of labourers, or interest with the borrowing of money, than economic rent with the hiring of land.

The main classes of the product are: (1) reproduced capital, and (2) income. Income can be classified into: (*a*) rent of immovable capital; (*b*) rent of movable capital; (*c*) rent of (scarce) personal ability; and (*d*) wages.

2. *The Class Wages necessarily determinate.*—The reaction against the wage-fund theory has been carried too far. The rejection of the limits of a predetermined fund has often led to the assumption of the potential illimitability of the share of wages within the total of the product. Or wages have been regarded as the residual element in a potentially illimitable total, only the three other classes of income being determinate. More careful definitions of the four classes of income should enable wages to be as strictly determined as the three others.

3. *The Income Classes individual Variants.*—The economic product is universally resultant from a combination of the factors of production, and no part of it can be ascribed to any particular one among those factors. The total varies according to the aggregate effectiveness of the combination of the factors, but the classification of the total according to their relation among themselves.

4. *Marginal Effectiveness.*—The relation among the factors of production is expressed by their marginal effectiveness. The limit of each income class is determined by (1) the marginal effectiveness of the corresponding factor in production, and (2) the excess of its total over its marginal effectiveness. The marginal effectiveness of land and skill is usually nil, and that of mobile capital is measured by the rate of (loan) interest; but in all these cases the excess of the total over the marginal effectiveness is great: the marginal and the total effectiveness of labour as such are necessarily identical, being the product of labour on the contemporary margin of utilisation of land, capital, and skill.

The class wages can accordingly never include any part of the result of the existence of immovable or movable material capital, or (scarce) personal capital,

superior in effectiveness to the very worst necessarily in use. Its limits (as well as theirs) prevent it trenching on any of the three other classes.

5. *The Effect of Income Classification upon Income Distribution.*—With unrestrained individual ownership, in perfect frictionless competition and universal omniscience, the objective distribution would constantly coincide with the subjective classification. Private property in capital, whether immovable or movable, necessarily involves the power to extract as mere 'rent' the equivalent of the whole economic advantage of all instruments of production exceeding in effectiveness the worst necessarily in use. The remuneration of those human beings who contribute their personal services cannot permanently exceed what they would produce with instruments merely of marginal effectiveness. Abstracting (scarce) personal capital, the ordinary labourer cannot permanently obtain, under individualism, more than his potential individual product at the very margin of utilisation of land, capital, and skill. He cannot possibly have any interest or share in fertile lands, superior machinery, or exceptional skill, which are, for him, virtually non-existent.

6. Application of the modern wage theory to co-operation, technical education, factory legislation, taxation, &c.

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4. *Report of the Committee on the teaching of Science in Elementary Schools.*—See Reports, p. 131.

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5. *Apprenticeship in the Engineering and Shipbuilding Trades.* *By* Sir Benjamin Browne, *D.C.L., M.Inst.C.E.*

Taking the trade of an engineer as typical of all the trades employed in engineering and shipbuilding, the writer describes the ordinary training of an apprentice who wishes to be a first-class workman. It is an object for him to be educated cheaply, and to earn some wages as soon as is practicable. Experience shows that apprenticeship generally should be six years, or five at least—preceded by good schooling.

To be a good mechanic long training is necessary; and, above all, to know good work from inferior work. A regular course of progress from one class of work to another should be carefully followed so as to teach every class of work up to the most difficult. In this the real interest of the employer is the same as that of the lad—viz., to learn every step thoroughly, and then pass on to something rather more difficult.

1. Is the training of a manufacturing workshop absolutely necessary, or can any substitute be found?

2. Is such training all that is necessary, or is anything else required to supplement it?

The writer contends that a long training in a manufactory is absolutely necessary, but that this certainly ought to be supplemented by theoretical and technical training.

Referring to the practice of employers as to the latter, the Elswick Works nearly forty years ago commenced the Elswick Mechanics' Institute, with science classes, for training their apprentices. This was less common then than it is now, and the good work done by this Institute has been very great.

Since then many good classes have been established in Newcastle; and when the firm R. & W. Hawthorn was reconstructed, in 1870, instead of commencing new classes the partners decided to pay the fees of every apprentice who attended any evening class approved by the firm. Besides evening classes, if it were possible, it would probably be a great gain to give a lad six or eight months of theoretical teaching when he was just out of his apprenticeship.

In a trade like plumbing there is a great opening for really good scientific teaching to supplement, not to supersede, the ordinary workshop education. This is now supplied in many places.

In boiler-making and shipbuilding it has to be borne in mind that a young boy is not physically able to do or learn much at first, so he may, if need be, get

another year or so at school; but in this case it is necessary, and the writer believes the Union insists, that he shall continue his apprenticeship after twenty-one, till he has served a sufficient time—a most wise arrangement.

As regards the class known as premium apprentices or pupils, these are young men who can afford to pay to receive exceptional training to enable them to take a higher position at an earlier age than they could do otherwise. To them, as to the others, there is no substitute for the manufactory as the proper place of education; but they may advantageously spend one or two years at college or at a technical school before or after apprenticeship. In this class no rule can be laid down, and every lad's case must be taken on its merits—with a view to his position and future prospects.

To conclude. The old-fashioned system of apprenticeship, not much shortened, and with very slight modifications, is the only reliable method for either employer or mechanic to learn his business; but as work has become more scientific and elaborate, it is absolutely necessary for any young man who wishes in any degree to excel that he should have a good theoretical and technical training in addition to his factory experience.

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6. *Technical Education. By* Dr. J. H. Rutherford.

The forces contributing to the decline of apprenticeship, mainly those tending to the specialisation of labour and the massing of workers in large factories. Specialisation of function involves the loss of versatility. On grounds of mere economy we must cultivate man's higher nature.

In olden time the apprentice had more varied work, and by close personal contact with his master felt the influence of his character and skill.

Impossible to resist the economic law, which leads to the subdivision of labour: the question is how to secure for young beginners in the workshop the best possible training. The duties of employers, of foremen, of workmen, and of learners themselves to do each their part in the work. Kindly personal leading the great want, for which no amount of educational machinery can compensate.

The first duty of the nation to broaden, to liberalise, and to perfect the common school education. Greater elasticity should be given to it. Boys and girls have to use their bodies as machines. They should, therefore, have some knowledge of the nature, construction, food, and work of those machines, and of the conditions under which their highest power can be most economically developed. The manual exercises of the infant school should be continued through all the standards. With the subjects of needlework, cookery, drawing, and modelling in clay added to these, the girls will find enough for the training of the eye and the hand. To these may be added joiner-work for the boys in the Sixth Standard; though it is an open question whether joiner-work should be commenced till the Sixth Standard is passed. Till then no special preparation should be attempted for any particular trade. No employer of labour, except under exceptional circumstances, should engage a child who has not passed the Sixth Standard of an elementary school, or an equivalent examination. There should be no half-timers, except those who under a medical certificate are declared incapable of bearing the strain of four or five hours' school work per day.

The things lying at the foundation of a sound system of technical education are these:—(1) The inheritance by our children of a strong physical constitution; (2) an improved physical education at school; (3) a longer stay at the common school; (4) an improved general education; (5) a higher moral training; (6) thorough instruction in the honourableness of manual labour, and in the duty and advantage of a busy, active, industrious life.

Under an improved system of primary education, an increasing number of children would be able, and would be induced to go forward to the secondary school. The physical and manual exercises of the elementary school should be continued and increased by laboratory work. Beyond that point it is doubtful whether they should be increased until the education of the perceptive and reasoning faculties is further advanced.

For occupations requiring special intelligence and skill mental discipline comes first in order of time and importance. Nor is it much less so in those occupations where human labour is reduced to the monotonous drudgery of a machine. The course of instruction in science and art laid down in the 'Science and Art Directory' would, with certain liberal modifications, mark the next stage in a curriculum of national technical education. Remodelled and liberalised, the Science and Art Department might give us a system of secondary schools well adapted to the wants of the country. No attempt should be made to ignore, far less to starve or suppress voluntary effort. Where that fails or is inadequate it should be the duty of some public body, preferably one elected for the purpose, to make the necessary provision. For the co-ordination of public educational work in the various localities, educational councils should be formed, with a proportionate representation of the different schools. The Science and Art Department should be largely staffed by men who are practical educationists. The responsible head of the Department should be advised by a council of men who have had experience in the management of the largest and most successful schools in the kingdom. The system of payment by results should either be abandoned, or it should be applied to all the institutions receiving Parliamentary grants, not excluding those under the immediate management of the Department itself. Higher grants, if the system is continued, should be given for passes in the advanced and honours stages. These grants should be somewhat proportioned to the labour and cost expended to attain them. Payment should be made for passes in all the subjects of a year taken by a student, so that the courses of instruction recommended by the Department are followed. Practical mechanics should, in the 'Science and Art Directory,' be placed in the same relationship to theoretical mechanics that practical chemistry and metallurgy do to theory in those subjects. The regulations regarding schools of art, which press so unduly and so severely upon industrial as compared with middle-class students, should be modified so as to prevent the industrial student from being handicapped in the national competition. The only guarantee that the Department should require as to works is that they have been executed by the student under the direction of the teacher. To enable committees and teachers to learn from their failures, the examination papers, when the Department have done with them, should be returned to the respective schools and classes from which they were sent up. With such reforms, and the addition of commercial and general subjects to the syllabus, a system of secondary public schools might be established well fitted to prepare for a true sound technical education.

Strictly speaking, that education can only be said to begin when the scientific principles on which the trade rests have been mastered, and when there is sufficient knowledge of art to enable the apprentice to read drawings with accuracy and facility. To reach that standard a course of three years' instruction will be required, and when that time cannot be given in the secondary day school it should be completed by attendance at the evening classes.

It is at this point that the apprentice should begin to specialise and apply his studies. He should also seek rapidly to acquire the manual dexterity and manipulative skill that will enable him to do his work well and quickly. In many trades that dexterity and skill can only be acquired in the actual workshop, the stimulus to rapidity of execution only there being found in sufficient force. There are, however, trades which, though they cannot be well learnt except in the workshop, have tools the nature and uses of which can profitably be taught in technical schools or colleges.

It is along these lines that we, at Bath Lane, have been endeavouring to advance. Our experience confirms the views expressed by Mr. Mather in his report on the position of the United States to the Royal Commissioners on Technical Education. He does not attribute the superiority of the American people in many branches of industry to the nature of their technical instruction, but to the high character of their common schools.

The light thrown by our statistics at Bath Lane on those points.

The mediæval corporation was known as a university, even though it was composed wholly of smiths or coopers or tailors. In the reign of Elizabeth it was

enacted that no person should exercise any trade or mystery without having served a seven years' apprenticeship. By the judges that statute was held as applying only to the trades then existing. All the new industries, such as those of Manchester and Birmingham, were thus exempt. Eventually, through the influence of the teachings of Adam Smith and the Political Economists in 1814, the statute of Elizabeth was wholly repealed. But we might escape the danger, monopoly, and exclusiveness without throwing away the advantages of thorough training. The trades' unions have, to some extent, taken the place of the ancient guilds, and it is for them to consider whether they would not confer a benefit upon their class and upon the country by requiring a certain term of apprenticeship, or some evidence of capacity for work from their members.

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7. *On Manual, or some form of Technical Instruction a necessary element of a Compulsory System of Education. By* EDWARD J. WATHERSTON.

The author points out that while school accommodation in England and Wales now exists for all the children who should be filling the seats, viz., 5,300,000, the average attendance in 1888 was only 3,630,000. This lamentable state of things existed in spite of the School Boards and School Attendance Committees, and of a costly central Department, and the fact that the annual expenditure on Elementary Schools exceeded 7,000,000*l.* sterling. His contention is that the instruction actually given in the schools was mechanical, lifeless, and uneducating; and his great point is that the remedy for the defective teaching and the bad attendance would be found in a system of manual and technical instruction, which would react on the ordinary subjects of education, and help to make the scholars more skilful and scientific handicraftsmen when they go into the world to earn their livelihood at the forge, the factory, the chemical works, or the loom. Quoting H.M. Inspectors Harrison, Blakiston, Scott Coward, on the quality of the children's attainments in the 'three R's,' he inquires what is being done for science teaching. Here he calls into requisition Sir H. Roscoe's evidence before the Royal Commission, who, together with Sir Philip Magnus, deplores its present poor quality, especially when contrasted with the condition of things in foreign countries. The author shows what is being done at the school in the Rue Tournefort, Paris. In this school the instruction comprehends the usual primary course, but great stress is laid on geometrical drawing, and in addition, the boys, instead of spending two or three hours a week, which are usually devoted in primary schools to cutting out designs in paper, spend about three hours a day in the workshop. This school is a liberal technical school in the best sense of the word. Everything made by the boys is first drawn out geometrically on paper to scale before being made. There are classes for carpentry, forging, metalwork, modelling, stone-carving and wood-carving. The school is admirably provided with abundance of tools. A very large number of models and other things have been given to the school, which inside is literally covered from floor to ceiling with the work of the pupils. It is this kind of school which the author desires to see established all over the country, and he suggests rearrangement of the school course into three divisions; the first to embrace children up to seven years of age, who should be instructed entirely on the Kindergarten methods. Reference is made to Mr. Scott Coward's warm praise of this method. From seven to eleven years of age the author would introduce elementary manual instruction, besides geometrical and freehand drawing. Here the teaching should not be trade or professional teaching, but formative and educative of hand and eye. For scholars over eleven he suggests distinctly technical and professional teaching, such as is given in the Rue Tournefort School or the Ecole Professionelle Municipale at Rheims, described by Sir Philip Magnus to the Royal Commission. 'Give the children an education that will be valuable to them, and we shall not be deploring the bad attendance at school. Why do not our workmen and foremen possess a sound knowledge of the science on which their industries depend?' The author complains strongly of the central Department, and asks for a simpler Code: the abolition of the Standard examination, and the banishment of

that 'frightful formula,' the percentage of passes. With absolute freedom to the localities as to the curriculum best adapted to the requirements of their children, and with entire liberty of classification to the teachers, we may hope for real improvement in our methods of teaching, and results which will be truly valuable to our industrial population.

TUESDAY, SEPTEMBER 17.

The following Papers and Reports were read:—

1. *On the Rate of production of Coal during the present Century.* *By* Professor EDWARD HULL, *LL.D.*, *F.R.S.*

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2. *Poor Law Progress and Reform, exemplified in the Administration of an East London Union.* *By* WILLIAM VALLANCE.

After an introductory reference to the still unsolved problem of poverty, and to the varied activities which have been called forth to stem the tide of human misery, the author said that nowhere was there, side by side with a sound policy of poor-law administration, more personal and practical interest in the well-being of the poor, a larger measure of co-operation between legal relief and voluntary charity, and a fuller recognition of the responsibilities which attach to churches and religious organisations in relation to service for the poor, than in the East End of London. Popularly regarded as a district of the metropolis in which wretchedness and criminality abound, it was yet strangely true how little the condition of its poor differed from that of other centres of population. Upon the basis of Mr. Charles Booth's tables, he stated roundly that in the Whitechapel Union the 'lower and upper middle classes' number $6\frac{1}{4}$ per cent.; the 'regular weekly workers' 71 per cent.; the 'irregular and casual workers' $19\frac{1}{2}$ per cent.; and the lowest class, which include 'loafers' and the criminal or semi-criminal classes, but $3\frac{1}{4}$ per cent.—figures which went far, he thought, to modify the general conception of its horrors. In this district the administrators of legal relief could now take a retrospect of twenty years' resolute adherence to sound principles of relief, and see moral consequences far outweighing statistical, or financial, results. Up to 1870 the relief system had been that of vicariously dispensing small doles of out-door relief; the in-door establishments being reserved for the destitute poor who voluntarily sought refuge in them; able-bodied men out of employment being set to work in a labour yard, and relieved in money and kind. Under this system the administration was periodically subjected to great pressure, the aid of the police being frequently invoked to restrain disorder, and to protect persons and property of the Guardians. The experience of the winter of 1869–70, however, was such as to lead the Guardians to review their position, and earnestly to aim at reforming a system which was felt to be fostering pauperism and encouraging idleness, improvidence, and imposture, while the 'relief' in no true sense helped the poor. It was seen that voluntary charity largely consisted of indiscriminate almsgiving, that it accepted no definite obligation as distinct from the function of poor-law relief, that the poor-law was relied upon to supplement private benevolence, that the alms-givers were too frequently the advocates of the poor in their demands upon the public rates, and that both poor-law and charity were engaged in relieving a distress much of which a thoughtless benevolence and a lax poor-law administration had created. They looked forward to the ultimate possibility of laying down a broad distinction between 'legal relief' and 'charitable aid,' and of interpreting the former as relief in the workhouse or other institution, and the latter as personal sympathy and help. The author then traced the processes of restriction (1) in 'out-of-work'

cases until, in the course of the year 1870, the labour yard was permanently closed; (2) in cases of sick men with families, who were relieved usually upon some condition of personal effort to avoid future recourse to the rates for support; (3) in those of widows with dependent children, who were relieved for a strictly limited period pending inquiries as to circumstances and possibilities, and efforts to place them in positions to achieve independence; and (4) in the cases of the 'aged and infirm,' in which relief was restricted as much as possible to those who gave evidence of thrift, and had no relatives capable of maintaining them; adding that even these exceptions and limitations became non-existent and unnecessary with the organisation of voluntary charity, which gradually undertook the benevolent work of saving the really deserving poor from the poor-law. Thus the door of out-relief became gradually closed, and, as a fact, no cases—other than those of urgent necessity, relieved by the relieving officer in kind—have now for some eighteen years been added to the out-door relief lists. The number of out-door paupers (remnants of a former system) now remaining chargeable is but five—all aged women. The statistical tables appended to the paper showed that, whereas in 1870 there were in one week 1,419 in-door paupers and 5,339 out-door paupers relieved, in the corresponding week of 1889 there were but 1,308 in-door paupers —including 137 imbeciles not previously classified—and 46 out-door—including 38 boarded-out children—relieved. In other words, whilst in 1870 79·0 per cent. of the paupers relieved were out-door, in 1889 but 3·4 per cent. were out-door. The cost of relief in money and kind in 1869 was 7,458*l.*, and in 1889, 117*l.* A further table gave the mean number of in-door and out-door paupers in each of the years 1870-89, from which it appeared that the mean number of in-door paupers in 1889 was 1,303, as compared with 1,311 in 1870; and that the mean number of out-door paupers in 1889 was 305 (including 216 lunatics in asylums, 41 in receipt of medical relief only, and 40 boarded-out children), as compared with 3,554 in 1870; and, further, that the ratio of pauperism to population in 1870 was 61·6 per 1,000, and in 1889, 22·5 per 1,000. The moral results of the system were next referred to in the direction of the improved condition of the poor, in their increased thrift and self-respect, and in the work of voluntary charity being more and more in the form of personal service and less in that of almsgiving. So uniform and strict has become the administration of legal relief, and so well understood is it, that an application for out-door relief is now seldom made to the Guardians. Simultaneous with the restriction of out-door relief has been the endeavour of the Guardians to make their workhouse a 'well-regulated' establishment, and contributory, as far as possible, to character and self-reliance, as well as deterrent to the idle malingerer. In this workhouse every pauper is employed to the extent of his ability and, as far as possible, at his own trade; the Guardians relying upon dissociation and continuous occupation for discipline, and the absence of extra diet for work, however skilled and useful, as a deterrent. The evening hours of the paupers are also usefully and profitably employed under male and female 'mental instructors,' whose aim is generally to exercise a salutary restraint upon conduct and conversation, and to inspire the paupers to renewed efforts to obtain an honest livelihood. Having referred to other departments of poor-law administration, and sought to justify the policy above indicated, the author submitted that the existing system of legal relief does not in itself meet the more pressing needs of the poor, and that the influence of its gradual restriction will be found in a corresponding increase of sympathy between classes, and an intelligent study of the many social questions which lie at the root of our pauperism. The work of co-operation was next dealt with, and its importance enforced; the close co-operation and earnest work of the Charity Organisation Society in dealing with the more pressing needs of the deserving poor being acknowledged, and a plea urged for more voluntary work in our workhouses and infirmaries in the dispauperisation of those who have fallen by the way, and especially in the restoration to a virtuous life of young fallen women. In conclusion, it was submitted that if, as the result of a gradual abolition of out-door relief in one union, it can be said that in-door pauperism has not thereby increased, that the poor do not rely upon the poor-law as they formerly did, that cases of 'starvation' are of rarer occurrence,

that wisely directed charity, working in concert with the poor law, has been stimulated, that the needy and deserving poor are more earnestly sought out, that the character of the poor has improved, and that both poor-law administrators and representatives of organised charity are now unitedly engaged in the work of bridging the gulf between rich and poor, and in stemming the tide of hereditary pauperism, the policy which has produced these results will at least be held worthy of earnest public attention.

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3. *Poor Law Administration. By the* Rev. W. Bury.

There are two conflicting opinions as to the intention of the Poor Law; one that it exists for the relief of distress, the other that it exists for the repression of pauperism. A brief review of the history of the subject will show which opinion is the more correct.

In the first instance we find the signal failure of charity alone to deal with the disease;

Next, the State interfering in self-defence, but defeated in its object by the severity of its measures;

Next, the State retaining its repressive measures and endeavouring to regulate charity.

Then, as pauperism increased, the passing of the Elizabethan Poor Law, by which a system of legal relief was established, limited in its scope and repressive in its nature, and under a vigorous administration of which pauperism received a check. Then the administration becomes lax, the disease breaks out again, the life of the State is threatened. Government interferes once more with the Poor Law of 1834, which reverts to the principles of the old Poor Law.

Finally, more recent history since 1834, and our own experience for the last twenty years, repeat the same lessons, viz., the demoralising effect of a Poor Law laxly administered solely as a system of relief, the necessity of a Poor Law which gives no scope for the indulgence of so-called charitable feelings, and which offers relief only in an unattractive form. In a word, Poor Law relief should only be given in the house. That this is possible and productive of the happiest results the experience of more than one union shows, *e.g.*, Atcham, Brixworth, Bradfield, St. Neots, and others among rural unions, and St. George's-in-the-East and Whitechapel in the metropolis.

What can be done by these could be done by all; and if not an inquiry by a Royal Commission, at all events an inquiry by the Local Government Board might be made into the reasons for the flagrant contrasts which exist in contiguous unions, with a view to a new departure in the above direction.

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4. *A National Pension Fund. By the* Rev. W. Moore Ede, *M.A.*

Interest in national insurance has been revived by the recent German legislation, which provides a complete system of national insurance for sickness, disablement, old age, and burial money.

In England we generally prefer to leave satisfaction of social needs to individual effort; but, when individualism proves inadequate, we supplement its efforts by municipal or national organisation, *e.g.*, the Education Act of 1870.

How far does individual effort provide adequate insurance?

The friendly societies have created a system of insurance whereby provision can be secured in sickness, and funeral money at death. Though open to criticism on financial grounds, the friendly societies are steadily endeavouring to overcome past financial mistakes, and place the societies on a sound basis.

The efforts of these honourable societies would be facilitated, and the working classes protected from the disaster of joining unsound branches, if the Government would institute an adequate system of inspection of accounts, and insist on due publicity being given.

Provision in sickness may be left to the efforts of self-help working through the organisations of the friendly societies and the benefit funds of the trade unions.

When we compare the number of members of these societies with the total population, and see how many remain unprovided for, it is manifest that the day may come when the nation may, following the lines of our Education policy, think it necessary to supplement the efforts of individualism by establishing a national organisation for provision in sickness, which those who have not availed themselves of existing individualistic efforts may be compelled to join.

Individualism has scarcely done anything towards making provision for old age, and yet such provision is one of our greatest social necessities.

The life of the weekly-wage earning class is shadowed by the prospect of an old age of poverty, privation, and dependence. Parochial experience of this.

As competition intensifies, willingness to employ men advanced in years decreases. Difficulty of estimating the extent of old age poverty. Reasons for thinking it probable that something like one-half of the population who live beyond 60 years of age are reduced to become recipients of some form of poor relief.

In the industrial classes 59·49 per cent. of those who attain manhood reach 60, and 49·19 reach 65 years of age.

The cost of an annuity of 12*l.* a year, purchased at 65 years of age, precludes the possibility of expecting the wage-earning classes generally to save sufficient for this purpose, and utterly impracticable to render such saving compulsory.

But an annuity of 5*s.* a week, payable at 65, can be purchased at 18 years of age by a weekly payment of 2½*d.*, at 21 by 3*d.* a week; or the same annuity may be purchased by the payment of 1*s.* 8*d.* a week for three years between the ages of 18 and 21.

Reasons for preferring in a national scheme that the contributions to the pension fund should be paid in the early years of working life, say, between the ages of 18 and 21, or in the case of apprentices 21–24:—(*a*) Removes the difficulty of arrears; (*b*) diminishes cost of collection; (*c*) necessitates a smaller contribution; (*d*) exacts it at the period of life when it is easiest for wage-earners to make the necessary sacrifice, because the income of artisans and labourers reaches its highest point in early manhood; (*e*) the demands on their wages for family necessities are then lightest.

Could the wage-earning classes bear such a deduction from their wages?

The majority of men could, but women's labour is so ill remunerated they could not.

Ought the whole amount be exacted as a contribution from wages?

The German insurance scheme exacts only one-third of the pension premium from the workman. One-third is paid by the employer, one-third by the State.

In Denmark a scheme has been adopted according to which the parish doubles the amount contributed by the working-man subscriber, and commutes it for a pension. It is proposed that in future 25 per cent. shall be added from the funds of the parish, and 75 per cent. from the funds of the State.

The justice of requiring rent and interest to contribute towards the support of the aged. The substitution of compulsory insurance for the poor law without requiring any contribution from rent and interest would remove a burden which the well-to-do now bear and place it on the poorest; therefore equity demands that part of the burden should be borne by taxation.

Proposal. All persons to be required to pay 6*l.* 10*s.* on reaching the age of 21, either in one payment, or by deductions from wages till such sum be contributed by them to the pension fund, and all persons on arriving at the age of 65 to receive a pension of 5*s.* a week.

Reasons why all persons, whether weekly-wage earners or not, should pay contributions to the pension fund.

Reasons why, notwithstanding the fact that part of the cost would be defrayed from general taxation, the proposal would not have a pauperising tendency.

The benefits which would result.

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5. *Home Colonisation. By the* Rev. HERBERT V. MILLS.

I. The necessity for work of a useful, self-supporting kind for the able-bodied unemployed poor. Badness of the present methods of relief. We pauperise men willing to work. The financial loss to the community, and the moral loss of the present system.

II. Explicit account of our proposal. Its principle:—The organisation of men and women thrown out of employment into colonies or industrial villages where they can supply each other's needs. Details:—Within the colony there must be (1) agricultural work, (2) manufacturing work; (3) it must be controlled by a director. It must produce and consume its own products as far as possible. It must therefore produce chiefly the necessaries of life—food, clothing, and shelter. Outline of proposed industrial village. How the workers will obtain the necessaries of life; how they will obtain luxuries; how they will be induced to consume their own products; how they will extend their own borders so as to provide for children and an increasing population.

III. Difficulties and possibility of carrying out this plan successfully.

.This idea is not novel. It has hitherto been the germ and seed plot of civilisation. It is not difficult for average men to obtain the necessaries of life out of an average soil. What the inhabitants accomplish on the Isle of St. Kilda in spite of bad climate, scanty soil, and without modern tools and implements.

The success of the self-contained South American colonies, and the English villages of the last century. What has been done at Frederiksoord.

The great difficulty of previous attempts to give work to the unemployed has been to find a market for the sale of the produce. We shall scarcely experience this difficulty.

The difference between this and Socialistic schemes. The difference between this and Feargus O'Connor's scheme. The co-operative nature of this effort.

IV. *Advantages* of Home Colonisation to the general community. Less helpless and hopeless poverty. Fewer aged poor to be maintained at the public expense. We shall have a true 'labour test' for idlers, and can get our knaves and dastards arrested, and take up a more initiative policy for the suppression of vagabondage. We shall reduce the number of temptations towards prostitution and crime. A contented working-class, having a direct interest in the soil, would be our best defence in time of war.

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6. *Third Report of the Committee on the best methods of ascertaining and measuring Variations in the Value of the Monetary Standard.*—See Reports, p. 133.

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7. *Report of the Committee appointed to inquire and report as to the Statistical Data available for determining the amount of the Precious Metals in use as Money in the principal countries, the chief forms in which the Money is employed, and the amount annually used in the Arts.*—See Reports, p. 164.

SECTION G.—MECHANICAL SCIENCE.

PRESIDENT OF THE SECTION—W. ANDERSON, M.INST.C.E.

THURSDAY, SEPTEMBER 12.

The PRESIDENT delivered the following Address:—

I HAVE had considerable difficulty in selecting a subject which should form the main feature of my Address. This meeting being held in Newcastle, it seemed almost imperative that I should dwell upon two industries which may be said to have had their genesis here; that I should direct your attention to the extraordinary development of the system of transmitting power by hydraulic agency, and the use of the same agency for lifting enormous weights or exerting mighty pressures, and that I should not neglect to notice a manufacture of specially national importance—that of heavy artillery, and of ships of war sent forth fully equipped and ready to take their places in our first line of defence.

The desire which I felt of treating of these subjects was heightened by the opportunity which it would have afforded of paying a tribute of respect and admiration to the distinguished citizen of this town who by his genius and perseverance created the Elswick Works, raised the character of British Engineering, and rendered his country services so eminent that her Majesty has seen fit to recognise them by bestowing honours higher than any which an engineer has hitherto been able to achieve.

But I felt that the themes mentioned, important as they are, have been frequently treated of by able men, and that I would perhaps render more service to Mechanical Science if I drew your attention to a subject which appears to me to be bearing with daily augmenting force on the practical manipulation of the materials used in construction. I allude to the molecular structure of matter. This branch of science has, up to the present time, been left very much in the hands of the chemist and the physicist, and I dare say that many engineers may think that it is by no means desirable to change the arrangement; but I am persuaded that the progress of engineering, the more exact methods of dealing with the properties of materials, the increased demands on their powers of endurance, render it imperatively necessary that mechanics should interest themselves more deeply in their internal structures and in the true meaning of the laws by which their properties are defined.

Five years ago, at Montreal, in his Address to the Mathematical Section, Sir William Thomson took for his subject the ultimate constitution of matter, and discussed, in a most suggestive manner, the very structure of the ultimate atoms or molecules. He passed in review the theories extant on the subject, and pointed out the progress which had been made in recent years by the labours of Clausius, of Clerk Maxwell, of Tait, and of others, among whom his own name, I may add, stands in unrivalled prominence.

I will not presume to enter into the field of scientific thought and speculation traversed by Sir William Thomson, because I am only too conscious that both my mathematical knowledge and my acquaintance with the natural sciences is too limited to entitle the views which I may have formed to any respect; I propose to

draw attention only to some general considerations, and to point out to what extent they practically interest the members of this Section.

In a lecture delivered at the Royal Institution last May, Professor Mendeléeff attempted to show that there existed an analogy between the constitution of the stellar universe and that of matter as we know it on the surface of the earth, and that from the motions of the heavenly bodies down to the minutest interatomic movements in chemical reactions the third law of Newton held good, and that the application of that law afforded a means of explaining those chemical substitutions and isomerisms which are so characteristic, especially of organic chemistry.

Examined from a sufficient distance, the planetary system would appear as a concrete whole, endowed with invisible internal motions, travelling to a distant goal. Taken in detail, each member of the system may be involved in movements connected with its satellites, and again each planet and satellite is instinct with motions which, there is good reason to believe, extend to the ultimate atoms, and may even exist, as Sir W. Thomson has suggested, in the atoms themselves. The total result is complete equilibrium, and, in many cases, a seeming absence of all motion, which is, in reality, the consequence of dynamic equilibrium, and not the repose of immobility or inertness.

The movements of the members of the stellar universe are, many of them, visible to the eye, and their existence needs no demonstration; but the extension of the generalisation just mentioned to substances lying, to all appearances, inert on the earth's surface is not so apparent. In the case of gases, indeed, it is almost self-evident that they are composed of particles so minute as to be invisible, in a condition of great individual freedom. The rapid penetration of odours to great distances, the ready absorption of vapour and of other gases, and the phenomena connected with diffusion, compression, and expansion seem to demonstrate this. One gas will rapidly penetrate another and blend evenly with it, even if the specific gravities be very different. The particles of gases are, as compared with their own diameters, separated widely from each other; there is plenty of room for additional particles; hence any gas which would, by virtue of its molecular motion, soon diffuse itself uniformly through a vacuum will also diffuse itself through one or more other gases, and once so diffused, it will never separate again. A notable example of this is the permanence of the constitution of the atmosphere, which is a mere mixture of gases. The oxygen and the nitrogen, as determined by the examination of samples collected all over the world, maintain sensibly the same relative proportions, and even the carbonic acid, though liable to slight local accumulations, preserves, on the whole, a constant ratio, and yet the densities of these gases differ very greatly.

Liquids, though to a much less degree than gases, are also composed of particles separated to a considerable relative distance from each other, and capable of unlimited motion where no opposing force, such as gravity, interferes; for under such circumstances their energy of motion is not sufficient to overcome the downward attractions of the earth; hence they are constrained to maintain a level surface.

The occlusion of gases without sensible comparative increase of volume shows that the component particles are widely separated. Water, for example, at the freezing-point occludes above one and three-quarter times its own volume of carbonic oxide, and about 480 times its volume of hydrochloric acid, with an increase of volume, in the latter case, of only one-third, and sulphuric acid absorbs as much as 600 times its bulk of methylic ether. The quantity of gas occluded increases directly as the pressure, which seems to indicate that the particles of the occluded gas are as free in their movements among the particles of the liquid as they would be in an otherwise empty containing vessel.

Liquids, therefore, are porous bodies whose constituent particles have great freedom of motion. It is no wonder, consequently, that two dissimilar liquids, placed in contact with each other, should interpenetrate one another completely, if time enough be allowed; and this time, as might be expected, is considerably greater than that required for the blending of gases, because of the vastly greater mobility of the particles of the latter. The diffusion of liquids takes place not only when

they are in actual contact, but even when they are separated by partitions of a porous nature, such as plaster of Paris, unglazed earthenware, vegetable or animal membranes, and colloidal substances, all of which may be perfectly water-tight in the ordinary sense of the term, but yet powerless to prevent the particles of liquids making their way through simultaneously in both directions.

The rate of diffusion increases with the temperature; but an increase of temperature, we know, is synonymous with increased molecular motion of the body, and with increased activity of this kind we would naturally look for more rapid interchanges of the moving atoms. Such phenomena are only conceivable on the supposition that active molecular motion is going on in an apparently still and inert mass.

When we come to solid substances the same phenomena appear.

The volumes of solids do not differ greatly from the volumes of the liquids from which they are congealed, and the solid volumes are generally greater. The volume of ice, for example, is one-tenth greater than that of the water from which it separates. Solid cast-iron just floats on liquid iron, and most metals behave in the same way; consequently, if the liquids be porous the solids formed from them must be so also; hence, as might be expected, solids also occlude gases in a remarkable manner. Platinum will take up five and a half times its own volume of hydrogen, palladium nearly 700 times, copper 60 per cent., gold 29 per cent., silver 21 per cent. of hydrogen and 75 per cent. of oxygen, iron from eight to twelve and a half times its volume of a gaseous mixture, chiefly composed of carbonic oxide.

Not only are gases occluded, but they are also transpired under favourable conditions of temperature and pressure, and even liquids can make their way through. Red-hot iron tubes will permit the passage of gases through their substance with great readiness. Ordinary coal gas, when under high pressure, is retained with difficulty in steel vessels, and it is well known that mercury will penetrate tin and other metals with great rapidity, completely altering their structure, their properties, and even their chemical compositions.

The evidence of the mobility of the atoms or molecules of solid bodies is overwhelming. Substances when reduced to powder, may, even at ordinary temperatures, be restored to the homogeneous solid condition by pressure only. Thus, Professor W. Spring, some ten years ago, produced from the powdered nitrates of potassium and sodium, under a pressure of thirteen tons to the square inch, homogeneous transparent masses of slightly greater specific gravity than the original crystals, but not otherwise to be distinguished from them. More than that, from a mixture of copper filings and sulphur he produced, under a pressure of thirty-four tons per square inch, perfectly homogeneous cuprous sulphide, Cu_2S, the atoms of the two elements having been brought, by pressure, into so intimate a relation to each other that they were able to arrange themselves into molecules of definite proportion; and, still more remarkable, the carefully dried powders of potash, saltpetre, and acetate of soda were, by pressure, caused to exchange their metallic bases and form nitrate of soda and acetate of potash.

The same movements and changes have taken place, and are still going on, in Nature's laboratory. During the countless ages with which geology deals, and under the enormous pressures of superincumbent masses, stratified sedimentary rocks become crystallised and assume the appearance of rocks of igneous origin, and not only so, but rocks of whatever origin, crushed and ground to pieces by irresistible geological disturbances, reconstruct themselves into new forms by virtue of the still more irresistible and constant action of molecular forces and movements. Those who had the privilege of hearing Professor A. Geikie's brilliant lecture at the Royal Institution last session will remember the striking series of microscopic slides which he exhibited, and by the aid of which he illustrated the changes of structure to which I have alluded.

At high temperatures the same effects are more easily produced on account of the greater energy of motion of the atoms or molecules. In the process of the manufacture of steel by cementation, or in case-hardening, the mere contact of iron with solid substances rich in carbon is sufficient to permit the latter

to work its way into the heart of the former, while in the formation of malleable cast-iron the carbon makes its way out of the castings with equal facility, it is a complete case of diffusion of solid substances through each other, but, on account of the inferior and restricted mobility of the particles at ordinary temperatures, a higher degree of heat and longer time are needed than with liquids or gases.

Again, when, by the agency of heat, molecular motion is raised to a pitch at which incipient fluidity is obtained, the particles of two pieces brought into contact will interpenetrate or diffuse into each other, the two pieces will unite into a homogeneous whole, and we can thus grasp the full meaning of the operation known as 'welding.' By the ordinary coarse methods but few substances unite in this way, because the nature of the operation prevents, or at any rate hinders, the actual contact of the two substances; but when molecular motion is excited to the proper degree by a current of electricity, the faces to be joined can be brought into actual contact, the presence of foreign substances can be excluded, and many metals not hitherto considered weldable, such as tool steel, copper, and aluminium, are readily welded, as many of us witnessed at the hands of Professor Ayrton in the highly instructive lecture on electricity delivered last year at our Bath meeting. Again, a mere superficial union of different metals takes place readily under the influence of high temperature and moderate pressure, as we see in the operations of tinning, soldering, and brazing. The surfaces of the metals must be made as clean as possible; the solder, which melts at a lower temperature than the metal to be soldered or brazed, is applied, and at a comparatively moderate temperature and under very slight pressure the particles interpenetrate each other; the two metals unite and form an alloy, by the intervention of which the two surfaces are joined. This effect is very well illustrated by the action which takes place at the surface of contact of two dissimilar liquids. If brine, for example, be placed in the lower part of a glass tube, and ordinary water, coloured in some way, be carefully poured on the top, a sharp plane of demarcation will appear, but in a short time the plane of separation will become blurred, and will ultimately disappear, a local blending of the two waters will take place, and will thus present a case of fluid-welding.

It seems plain, therefore, that apparently inert solid masses are also built up of moving particles in dynamic equilibrium, for without such an assumption it would be hard to explain the phenomena to which I have alluded. But in addition to this evidence we can adduce the effects of other forms of energy, which we recognise under the names of radiant heat, light, and electricity. These we know to be forms of motion which can be communicated and converted from one to the other, from the invisible to the visible. The movement which we term radiant heat, acting through the instrumentality of the luminiferous ether which is believed, on the strongest grounds, to pervade all space and all matter, is competent to augment the quantity of movement in the particles of substances, and generally to cause an enlargement of volume; and conversely, when the particles, by contact or radiation, part with their heat, either to surrounding objects or to space, the quantity of motion is reduced, the body contracts, and this contraction goes on down to temperatures far below those at which we have to work in practice, and consequently at all ordinary temperatures there must be abundant room for molecular motion.

Again, energy in the form of light operates changes in the surface of bodies, causing colours to fade, and giving to photography the marvellous power which it possesses; decomposing the carbonic acid of the atmosphere in the chlorophyl of green leaves, and determining chemical combinations, such as chlorine with hydrogen to form hydrochloric acid, or carbonic oxide with chlorine to form chlorocarbonic acid. It is inconceivable that these effects could be produced unless the undulations of light were competent to modify the molecular motions already existing in the solid liquid and gaseous bodies affected.

Electricity exerts a similar influence. Generated by the molecular movements caused by chemical activity, whether directly, as in the primary battery, or indirectly, as in the dynamo, it is competent to increase the molecular movements

in bodies so as to produce the effects of heat directly applied; it is capable of setting up motions of such intensity as to produce chemical changes and decompositions, to say nothing of the whole series of phenomena connected with magnetism, with induction, or the action through space and through non-conducting bodies, which, as in the case of radiant heat and light, seems to imply the existence of an interatomic ether. Conversely, changes of molecular equilibrium, brought about by the action of external forces, produce corresponding changes in electrical currents: witness the effects of heat, for example, on conductivity and the wondrous revelations of molecular change obtained by the aid of Professor Hughes's induction balance. The behaviour of explosives illustrates also, and in a striking manner, the effects of disturbing molecular equilibrium. An explosive is a substance which contains in itself, in a solid or liquid form, all the elements necessary to produce a chemical change by which it is converted into the gaseous state. The application of heat, of pressure, or of impact, causes, as in Professor Spring's experiments, chemical union to take place, first at the spot where the equilibrium is disturbed by the application of external force, and afterwards, with great rapidity, throughout the mass, the disturbance being propagated either by the air surrounding the particles or by the luminiferous ether, with all the rapidity of light; the chemical reaction is accelerated by the pressure which may arise, for example, if the explosive be confined in the chamber of a gun or in the bore-hole of a blast. High explosives, as they are termed, are comparatively inert to ordinary ignition; but when the molecular equilibrium is suddenly disarranged throughout the mass by the detonation of a percussion fuse, combination takes place instantly throughout, and violent explosion follows. In a similar manner some gases, such as acetylene, cyanogen, and others, can be decomposed by detonation and reduced to their solid constituents. Professor Thorpe has devised a very beautiful lecture experiment, in which carbon disulphide is caused to fall asunder into carbon and sulphur by the detonation of fulminate of mercury fired by an electric spark. In these cases a reverse action takes place, but illustrates equally well the conversion of one form of energy into others, and the consequent disturbance of molecular equilibrium in the substances affected. It seems to me clear, therefore, that the time has come when the conception of dynamic equilibrium in the ultimate particles of matter in all its forms must take the place of the structural system of inert particles. I cannot conceive how the phenomena which I have enumerated can be explained on the supposition that matter is built up of motionless particles—how, for example, a stack of red and yellow bricks could ever change the order of arrangement without being completely pulled asunder and built up again, in which case an intermediate state of chaos would exist; but I can easily comprehend how a dense crowd of people may appear as a compact mass, streaming, it may be, in a definite direction, and yet how each member of that mass is endowed with limited motion, by virtue of which he may push his way through without disturbing the general appearance; how the junction of two crowds would form one whole, though, perchance, altered in character; and how even Professor Spring's experiments may be explained by the supposition that bystanders on the edge of a crowd would be forced, by external pressure, to form part of it and partake of its general movements.

It is a suggestive fact that the product of the atomic weight of certain groups of substances and their specific heats is a constant quantity which, for the greater number of the elements, does not differ much from 6·5. This implies that the quantity of heat necessary to raise the temperature of the atoms of any one of the groups to any given extent is the same; hence these atoms will be endowed with the same amount of energy at any given temperature, and therefore would be competent to replace each other without disturbing the general dynamic equilibrium.

When it is conceded that molecular motion pervades matter in all its forms, and that the solid passes, often insensibly, into the fluid, or even direct into the gaseous, it follows, almost of necessity, that there must be a borderland, the limits of which are determined by temperature and pressure, in which substances are constantly changing from one state to another. This is observable in fusion, but to a more marked degree in evaporation, where the particles are being incessantly launched into space as gas and return as constantly to the liquid state. Henri St. Claire

Deville has investigated similar phenomena in chemical reactions; he has found that at certain temperatures and pressures substances fall asunder and combine much in the way in which evaporation takes place, and has given the name of 'dissociation' to this property of matter. Professor Mendeléeff and others have extended the great French chemist's observations, and have formulated the general law that substances are capable of dissociation at all temperatures, not only in the case of chemical unions, but also in that of solutions.

If steel be looked upon as a solution of carbon and iron, then the hardening of steel is explained by the theory that dissociation has taken place at the temperature at which it is suddenly cooled, the sudden cooling fixing the molecular motion at such an amplitude or phase that it gives a characteristic structure, one of the properties of which is extreme hardness. In tempering, the gradual communication of heat causes dissociation again to take place, the molecular equilibrium is modified by the increased energy imparted to the particles, and when suddenly cooled at any point there remains again a distinct substance, composed of iron and carbon, partly in various degrees of solution and partly free, and again possessing special mechanical qualities. That steel, and probably other alloys, differ in the nature of their composition according to the way in which they are worked, both with respect to heat and mechanical pressure, has been abundantly proved by many eminent metallurgists, and especially by Sir Frederick Abel, in the extended researches which he has recently carried out, on the hardening of steel, for the Institution of Mechanical Engineers, and it would appear as a natural sequence that the properties of steel would be greatly affected by the manner in which its temperature was changed, as we indeed find that it is when these changes are produced by baths of melted metals, by oil, or by water at different temperatures. The action which takes place may be illustrated by what would happen supposing that a complicated dance, such as the Lancers, were suddenly stopped in various phases of the figures. The component parts would always remain the same, but the relative distribution of the partners would vary continually, and analysis would show that at one time each gentleman was associated with a particular lady; at another, that two ladies were attached to a single gentleman, while a number of gentlemen had no partners at all; and yet, again, at another, that the movements which were once rectilinear have become circular. In each case the groups would assume a totally distinct appearance.

In support of these views it may be stated that, as far as I know, no pure element is capable of being hardened or tempered, the reason being that no chemical change can take place when there is only one substance; the effect of heat or pressure, however suddenly applied, produces merely a change of form which does not appear to carry with it any corresponding alteration of mechanical properties.

It may be urged, however, that it is unlikely that alloys or solutions could be affected in a manner so marked merely by small changes at comparatively low temperatures; but I would observe that 'great and little' are relative terms, and we have abundant evidence of the immense effects produced by what would be called 'little' causes. Sir Frederick Bramwell, in his address last year, drew attention to the importance of the 'next to nothing.' It is not so very long ago that anyone would have been considered a dreamer for propounding a theory that the presence of the fraction of a per cent. of carbon, phosphorus, or sulphur would totally alter the character of iron; that the addition of one two-thousandth part of aluminium to molten iron would make the pasty mass as fluid as water; that the presence of the smallest impurity in copper would have a disastrous effect on its powers of conducting electricity; and that the addition of one thousandth part of antimony would convert the 'best selected' copper into the worst conceivable. I need hardly allude to the great part played in nature by microscopic organisms, and how much of the beauty of our seas and rivers is derived from substances so minute that nothing but the electric beam of Professor Tyndall is capable of revealing their presence.

There is one more circumstance connected with my subject to which I must draw your attention, because, though its application to the mechanical properties

of substances is very recent, it promises to be of great importance. I allude to the Periodic Law of Dr. Mendeléeff. According to that law, the elements, arranged in order of their atomic weights, exhibit an evident periodicity of properties, and as Professor Carnelley has observed, the properties of the compounds of the elements are a periodic function of the atomic weights of their constituent elements. Acting on these views, Professor Roberts-Austen has recently devoted much time and labour to testing their exactness with reference to the mechanical properties of metals. The investigation is surrounded by extraordinary difficulties, because one of the essential features of the inquiry is that the metals operated on should be absolutely pure. For chemical researches, a few grains of a substance are all that is needed, and the requisite purity can be obtained at a moderate cost of time and labour; but when mechanical properties have to be determined considerable masses are needed, and the funds necessary for obtaining these are beyond the reach of most private individuals. I cannot help suggesting that wealthy institutions, such as many of those connected with our profession, could not employ their resources more wisely than in giving the means of following up the researches which Professor Roberts-Austen has inaugurated.

In view of the difficulty of obtaining metals of sufficient purity, he selected gold as his base, because that metal can be more readily brought to a state of purity than any other, and is not liable to oxidation. In a communication to the Royal Society made last year he shows that the metals alloyed with gold which diminish its tenacity and extensibility have high atomic volumes, while those which increase these properties have either the same atomic volumes as gold or have lower ones. The inquiry has only just been commenced, but it appears to me to promise results which, to the engineer, will prove as important and as fruitful of progress as the great generalisation of Mendeléeff has been to chemists. A law which can not only indicate the existence of unknown elements but which can also define their properties before they are discovered, if capable of application to metallurgy, must surely yield most valuable results, and will make the compounding of alloys a scientific process instead of the lawless and haphazard operation which it is now.

The practical importance of the views I have enunciated are, I think, sufficiently obvious. Every one will admit that an external force cannot be applied to a system in motion without affecting that motion; consequently matter, in whatever state, cannot be touched without changes taking place, which will be more or less permanent. The application of heat will cause a change of volume, and, at last, a change of condition; the application of external stresses will also produce a change of volume; and it is natural to infer that there must be some relation between the two, and, accordingly, Professor Carnelley has drawn attention to the fact that the most tenacious metals have high melting-points, though here again there is a great want of exactness, partly on account of the difficulty of measuring high temperatures, and partly by reason of the scarcity of pure materials.

Again, long-continued stresses, or stresses frequently applied, may be expected to produce permanent changes of form, and so we arrive at what is termed the fatigue of substances. Stretched beyond their elastic limits, which limits I do not suppose to exist except when stresses are applied quickly, substances are permanently deformed, and the same effects follow the long application of heat. The constant recurrence of stresses, even those within the elastic limit, causes changes in the arrangement of the particles of substances which slowly alter the properties of the latter, and in this way pieces of machinery, which theoretically were abundantly strong for the work they had to perform, have failed after a more or less extended period of use. The effect is intensified if the stresses are applied suddenly, if they reach nearly to the elastic limit, and if they are imposed in two or more directions at once, for then the molecular disturbance becomes very intense, the internal equilibrium is upset, and a tendency to rupture follows. Such cases occur in artillery, in armour-plates, in the parts of machinery subject to impact; and, as might be expected, the destructive effects do not always appear at once, but often after long periods of time.

When considerable masses of metal have to be manipulated by forging or by pressure in a heated condition, the subsequent cooling of the mass imposes restric-

tions on the free movement of some, if not all, of the particles; internal stresses are developed which slowly assert themselves, and often cause unexpected failures. In the manufacture of dies for coining purposes, of chilled rollers, of shot and shell hardened in an unequal manner, spontaneous fractures take place without any apparent cause, and often after long delay, the reason being that the constrained molecular motion of the inner particles gradually extends the motion of the outer ones until a solution of continuity is caused.

Similar stresses occur in such masses as crank shafts, screw shafts, gun hoops, &c. The late General Kalakoutsky some seventeen years ago commenced a systematic investigation into the internal stresses in the tubes and hoops of guns and in armour-piercing shells. The method he pursued was to cut discs or rings about half an inch thick off the hoops and shells, to divide the metal of each disc into from four to six rings, to fix by means of silver plugs, on which very finely marked cross-lines were drawn, from four to eight points on the surface of each ring, and then to measure, with extreme exactness, the changes in diameter produced in every ring by the successive cutting out of the rings. Knowing by direct tests the mechanical properties of his material, he was able, from the changes in the diameters, to calculate what the tangential stresses in every part of each disc were, and to draw inferences as to their fitness for the work they were intended to perform. The same method of investigation has been pursued by Captain Noble of the Elswick Works, and by Lieutenant Crozier of the United States artillery, with the practical result that probably much more attention will be paid in future to the principles on which the annealing and hardening of steel is carried on. A gun hoop or tube, to be in the best condition to resist a bursting stress, should have its inner surface in a state of compression, and its outer in a state of tension, and the hoops should be shrunk on to the tubes or on to each other with but very little pressure. General Kalakoutsky proposed, in order to set up beneficial internal stresses, that tubes which were being annealed should be cooled from the inside by a jet of steam, of air, of water, or of oil; and he advocated the practice of testing the effects of each new method of manufacture or of treatment by the careful measurements of slices of the finished material instead of working at random, as is still very much the practice. It is evident, also, that a sample of steel cut out of a gun hoop or crank shaft, and tested, can afford no indication of the available tenacity of the same sample *in situ*. When released from the constraint of its surroundings, the particles must, of necessity, change their condition, for the disturbing forces have been removed; and the probability is that, if the steel be good, the test will prove satisfactory, especially if some time be allowed to elapse between cutting out the sample and testing it, and a false security will be engendered such as has often led to disastrous results.

The influence of time on steel seems to be well established; the highest qualities of tool steel are kept in stock for a considerable period; and it seems certain that bayonets, swords, and guns are liable to changes which may account for some of the unsatisfactory results which have manifested themselves at tests repeated after a considerable interval of time. As all these things have been hardened and tempered, there must necessarily have been considerable constraint put upon the freedom of motion of the particles. This constraint has gradually been overcome, but at the expense of the particular quality of the steel which it was originally intended to secure.

I have now laid before you the views respecting the constitution of matter which I think are gaining ground, which explain many phenomena with which we are familiar, and which will serve as guides in our treatment of metals, and especially of alloys; but I must admit that the subject is still by no means clear, that a great deal more definition is wanted, and that we are still awaiting the advent of the man who shall do for molecular physics what Newton did for astronomy in explaining the structure of the universe.

One of the most remarkable features of the last thirty years is the introduction of petroleum, and the wonderful development to which the trade in it has attained.

Under the generic name of petroleum are embraced a vast variety of combi-

nations of carbon and hydrogen, each of which is distinguished by some special property. At ordinary temperatures and pressures some are gaseous, some are liquid, and some solid, and most are capable of being modified by suitable treatment under various temperatures and pressures. The employment of petroleum in the arts is still extending rapidly. Used originally for illuminating purposes, it is now employed as fuel for heating furnaces and steam-boilers; as a working agent in heat engines, valuable medicinal properties have been discovered; and as a lubricant it stands unrivalled.

As an illuminant, even in this country, it is, to a large extent, superseding every other in private houses, and even in public lamps, because it gives a cheaper and more brilliant light than ordinary gas, and leaves the consumer free from the tyranny of great and privileged companies.

As fuel it is especially convenient, cleanly, and economical. Stored in tanks of suitable construction, it is sprayed into the furnace without labour and without creating dust and dirt; and it is especially convenient in locomotive and marine work on account of the rapidity, ease, and cleanliness with which it can be run into the tender or into the oil-bunkers of a ship. As a working agent in heat engines it is employed in two ways. First as a vapour, generated from the liquid petroleum contained in a boiler, very much in the same way as the vapour of water is used in an engine with surface condenser, the fuel for producing the vapour being also petroleum. Very signal success has been obtained by Mr. Yarrow and others in this mode of using mineral oil, especially for marine purposes and for engines of small power; there seems to be no doubt that by using a highly volatile spirit in the boiler a given amount of fuel will produce double the power obtainable by other means, and at the same time the machinery will be lighter and will occupy less space than if steam were the agent used. The other method is to inject a very fine spray of hot oil, associated with the proper quantity of air, into the cylinder of an ordinary gas-engine, and ignite it there by means of an electric spark or other suitable means. Attempts to use oil in this way date back many years, but it was not till 1888 that Messrs. Priestman Brothers exhibited at the Nottingham Show of the Royal Agricultural Society an engine which worked successfully with oil, the flashing point of which was higher than 75° F., and was therefore within the category of safe oils. The engine exhibited was very like an ordinary Otto gas-engine, and worked in exactly the same cycle. A pump at the side of the engine forced air into a small receiver at a few pounds' pressure to the square inch. The compressed air, acting by means of a small injector, carried with it the oil in the form of fine spray, which issued into a jacketed chamber heated by the exhaust, in which the oil was vaporised. The mingled air and oil was thus raised to a temperature of about 300°, and was then drawn, with more air, into the cylinder, where, after being compressed by the return stroke of the piston, it was exploded by an electric spark, and at the end of the cycle the products of combustion were discharged into the air after encircling the spray chamber and parting with most of their heat to the injected oil. The results of careful experiments made by Sir William Thomson and by myself on different occasions were, that 1·73 lb. of petroleum were consumed per brake-horse power per hour; but the combustion was by no means perfect, for a sheet of paper held over the exhaust pipe was soon thickly spattered with spots of oil.

At the Windsor Show of the Royal Agricultural Society this year, Messrs. Priestman again exhibited improved forms of their engine; the consumption of oil fell to 1·25 lb. per brake-horse power per hour, and a sheet of paper held over the exhaust remained perfectly clean. They also showed a portable engine of very compact construction, and quite adapted to agricultural use; the ordinary water cart, which has, in any case, to attend a portable steam-engine, being adapted to supply the water necessary to keep the working cylinder of the engine cool.

It is hardly necessary to state that the use of petroleum for furnace purposes of all kinds is increasing very rapidly, and the demand has naturally reacted on the supply in promoting improved means of transport; and Newcastle, again, has led the van in this matter, for Sir William Armstrong, Mitchell & Co. have sent out a fleet of steamers constructed to carry the oil in bulk with perfect safety, both as

regards the stowage of a cargo so eminently shifting, and with respect to risk from fire and from explosion.

The enormous consumption of petroleum and of natural gases frequently raises the question as to the probability of the proximate exhaustion of the supply; and, without doubt, many fear to adopt the use of oil, from a feeling that if such use once becomes general the demand will exceed the production, the price will rise indefinitely, and old methods of illumination, and old forms of fuel, will have to be reverted to. From this point of view it is most interesting to inquire what are the probabilities of a continuous supply; and such an investigation leads at once to the question, 'What is the origin of petroleum?' In the year 1877 Professor Mendeléeff undertook to answer this question; and as his theory appears to be very little known, and has never been fully set forth in the English language, I trust you will forgive me for laying a matter so interesting before you. Dr. Mendeléeff commences his essay by the statement that most persons assume, without any special reason—excepting, perhaps, its chemical composition—that naphtha, like coal, has a vegetable origin. He combats this hypothesis, and points out, in the first place, that naphtha must have been formed in the depths of the earth. It could not have been produced on the surface, because it would have evaporated; nor over a sea bottom, because it would have floated up and been dissipated by the same means. In the next place he shows that naphtha must have been formed beneath the very site on which it is found—that it cannot have come from a distance, like so many other geological deposits, and for the reasons given above, namely, that it could not be water-borne, and could not have flowed along the surface, while in the superficial sands in which it is generally found no one has ever discovered the presence of organised matter in sufficiently large masses to have served as a source for the enormous quantity of oil and gas yielded in some districts; and hence it is most probable that it has risen from much greater depths under the influence of its own gaseous pressure, or floated up upon the surface of water, with which it is so frequently associated.

The oil-bearing strata in Europe belong chiefly to the Tertiary or later geological epochs; so that it is conceivable that in these strata, or in those immediately below them, carboniferous deposits may exist and may be the sources of the oil; but in America and in Canada the oil-bearing sands are found in the Devonian and Silurian formations, which are either destitute of organic remains, or contain them in insignificant quantities. Yet if the immense masses of hydrocarbons have been produced by chemical changes in carboniferous beds, equally large masses of solid carboniferous remains must still exist; but of this there is absolutely no evidence, while cases occur in Pennsylvania where oil is obtained from the Devonian rocks underlying compact clay beds, on which rest coal-bearing strata. Had the oil been derived from the coal, it certainly would not have made its way downwards; much less would it have penetrated an impermeable stratum of clay. The conclusion arrived at is, that it is impossible to ascribe the formation of naphtha to chemical changes produced by heat and pressure in ancient organised remains.

One of the first indices to the solution of the question lies in the situation of the oil-bearing regions. They always occur in the neighbourhood of, and run parallel to, mountain ranges,—as, for example, in Pennsylvania, along the Alleghanies; in Russia, along the Caucasus. The crests of the ranges, formed originally of horizontal strata which had been forced up by internal pressure, must have been cracked and dislocated, the fissures widening outwards, while similar cracks must have been formed at the bases of the ranges; but the fissures would widen downwards, and would form channels and cavities into which naphtha, formed in the depths to which the fissures descended, would rise and manifest itself, especially in localities where the surface had been sufficiently lowered by denudation or otherwise.

It is in the lowest depths of these fissures that we must seek the laboratories in which the oil is formed; and once produced, it must inevitably rise to the surface, whether forced up by its own pent-up gases or vapours, or floated up by associated water. In some instances the oil penetrating or soaking through the surface layers loses its more volatile constituents by evaporation, and, in consequence,

deposits of pitch, of carboniferous shales, and asphalte take place; in other cases, the oil, impregnating sands at a lower level, is often found under great pressure, and associated with forms of itself in a permanently gaseous state. This oil may be distributed widely according to the nature of the formations or the disturbances to which they have been subjected; but the presence of petroleum is not in any way connected with the geological age of the oil-bearing strata: it is simply the result of physical condition and of surface structure.

According to the views of Laplace, the planetary system has been formed from incandescent matter torn from the solar equatorial regions. In the first instance this matter formed a ring analogous to those which we now see surrounding Saturn, and consisted of all kinds of substances at a high temperature, and from this mass a sphere of vapours, of larger diameter than the earth now has, was gradually separated. The various vapours and gases which, diffused through each other, formed at first an atmosphere round an imaginary centre, gradually assumed the form of a liquid globe and exerted pressures incomparably higher than those which we experience now at the base of our present atmosphere. According to Dalton's laws, gases, when diffused through each other, behave as if they were separate; hence the lighter gases would preponderate in the outer regions of the vaporous globe, while the heavier ones would accumulate to a larger extent at the central portion, and at the same time the gases circulating from the centre to the circumference would expand, perform work, would cool in consequence, and at some period would assume the liquid or even the solid state, just as we find the vapour of water diffused through our present atmosphere does now. That which is true of changes of physical condition, Henri St. Claire Deville, in his brilliant theory of dissociation, has shown to be equally true with respect to chemical changes; and the cooling of the vapours forming the earth while in its gaseous condition was necessarily accompanied by chemical combinations, which took place chiefly on the outer surface, where oxides of the metals were formed; and as these are generally less volatile than the metals themselves, they were precipitated on to what there then was of liquid or solid of the earth, in the form of metallic rain or snow, and were again probably decomposed, in part at least, to their vaporous condition. The necessary consequence of this action is that the inner regions of the earth must consist of substances the vapours of which have high specific densities and high molecular weights—that is to say, composed of elements having high atomic weights—and that the heavier elementary substances would collect nearer the centre, while the lighter ones would be found nearer the surface. Our knowledge of the earth's crust extends but to an insignificant distance; yet, as far as we do know it, we find that the arrangement above indicated prevails. Hydrogen, carbon, nitrogen, oxygen, sodium, magnesium, aluminium, silicon, phosphorus, sulphur, chlorine, potassium, calcium, substances whose atomic weights range from 1 to 40, became condensed, entered into every conceivable combination with each other, and produced substances the specific gravity of which averages about $2\frac{1}{2}$, never exceeds 4, and are found near the immediate surface of the globe.

But the mean specific gravity of the earth as determined by Maskelyne, Cavendish, and others certainly exceeds 5, and consequently the inner portion of our globe must be composed of substances heavier than those existing on the surface, and such substances are only to be found among the elements with high atomic weights. The question arises, What elements of this character are we likely to find in the depths of the earth? In the first place, since gases diffuse through each other, a certain proportion of the elements of high atomic weight will also be found on the surface of the earth. Secondly, the elements forming the bulk of the earth must be found in the atmosphere of the sun—if, indeed, the earth once formed part of its atmosphere; and of all the elements, iron, with a specific gravity exceeding 7, and with an atomic weight of 56, corresponds best with these requirements, for it is found in abundance on the surface of the earth; and the spectroscope has revealed the very marked presence of iron in the sun, where it must be partly in the fluid and partly in the gaseous state; and consequently iron in large masses must exist in the earth; so that the mean specific gravity of our planet may well be 5, the value which has been determined by independent means.

It is not easy, however, to define in what condition the mass of iron which must exist in the heart of the earth is likely to be. Iron is capable of forming a vast number of combinations, depending upon the relative proportion of the various elements present. Thus, in the blast-furnace, oxygen, carbon, nitrogen, calcium, silicon, and iron are associated, and produce, under the action of heat, besides various gases, a carburet of iron and slag, the latter containing chiefly silicon, calcium, and oxygen—that is to say, substances similar to those which form the bulk of the surface of the earth. But these same elements, if there be an excess of oxygen, will not yield any carburet of iron; and the same result will follow if there be a deficiency of silicon and calcium, because of the large proportion of oxygen which they appropriate. In the same way, during the cooling of the earth, if oxygen, carbon, and iron were associated, and if the carbon were in excess of the oxygen, the greater part of the carbon would escape in the gaseous state, while the remaining part would unite with the iron. It is certain that, in the heart of the earth, there must have been a deficiency of oxygen, because of its low specific gravity; and the argument is supported by the fact that free oxygen and its compounds, with the lighter elements, abound on the surface. Further, it must be presumed that much of the iron existing at great depths must be covered over and protected from oxygen by a coating of slag; so that, taking all these considerations into account, it is reasonable to conclude that deep down in the earth there exist large masses of iron in part at least in the metallic state or combined with carbon.

The above views receive considerable confirmation from the composition of meteoric matter, for it also forms a portion of the solar system, and originated, like the earth, from out of the solar atmosphere. Meteorites are most probably fragments of planets, and a large proportion of them include iron in their composition, often as carbides, in the same form as ordinary cast-iron—that is to say, a part of the carbon is free and a part is in chemical union with the iron. It has been shown, besides, that all basalts contain iron, and basalts are nothing more than lavas forced by volcanic eruptions from the heart of the earth to its surface. The same causes may have led to the existence of combinations of carbon with other metals.

The process of the formation of petroleum seems to be the following: It is generally admitted that the crust of the earth is very thin in comparison with the diameter of the latter, and that this crust encloses soft or fluid substances, among which the carbides of iron and of other metals find a place. When, in consequence of cooling or some other cause, a fissure takes place through which a mountain range is protruded, the crust of the earth is bent, and at the foot of the hills fissures are formed; or, at any rate, the continuity of the rocky layers is disturbed, and they are rendered more or less porous, so that surface waters are able to make their way deep into the bowels of the earth, and to reach occasionally the heated deposits of metallic carbides, which may exist either in a separated condition or blended with other matter. Under such circumstances it is easy to see what must take place. Iron, or whatever other metal may be present, forms an oxide with the oxygen of the water; hydrogen is either set free or combined with the carbon which was associated with the metal, and becomes a volatile substance—that is, naphtha. The water which had penetrated down to the incandescent mass was changed into steam, a portion of which found its way through the porous substances with which the fissures were filled, and carried with it the vapours of the newly formed hydrocarbons, and this mixture of vapours was condensed wholly or in part as soon as it reached the cooler strata. The chemical composition of the hydrocarbons produced will depend upon the conditions of temperature and pressure under which they are formed. It is obvious that these may vary between very wide limits, and hence it is that mineral oils, mineral pitch, ozokerit, and similar products differ so greatly from each other in the relative proportions of hydrogen and carbon. I may mention that artificial petroleum has been frequently prepared by a process analogous to that described above.

Such is the theory of the distinguished philosopher, who has framed it not alone upon his wide chemical knowledge, but also upon the practical experience derived from visiting officially the principal oil-producing districts of Europe and America, from discussing the subject with able men deeply interested in the oil

industry, and of collecting all the available literature on the subject. It is needless to remark that Dr. Mendeléeff's views are not shared by every competent authority; nevertheless the remarkable permanence of oil-wells, the apparently inexhaustible evolution of hydrocarbon gases in certain regions, almost forces one to believe that the hydrocarbon products must be forming as fast as they are consumed, that there is little danger of the demand ever exceeding the supply, and that there is every prospect of oil being found in almost every portion of the surface of the earth, especially in the vicinity of great geological disturbances. Improved methods of boring wells will enable greater depths to be reached; and it should be remembered that, apart from the cost of sinking a deep well, there is no extra expense in working at great depths, because the oil generally rises to the surface or near it. The extraordinary pressures, amounting to 300 lbs. per square inch, which have been measured in some wells seem to me to yield conclusive evidence of the impermeability of the strata from under which the oil has been forced up, and tend to confirm the view that it must have been formed in regions far below any which could have contained organic remains.

The weights and measures in use in this country are a source of considerable trouble and confusion. Besides the imperial measures, which are complicated enough, a great number of local units are in use, so that unwary strangers are not unfrequently deceived, or, at any rate, if they hope to escape from mistakes, have to apply themselves to the study of local customs. In the scientific world, again, the metric system is now almost exclusively used, and the same may be said of engineers and manufacturers who have to do with foreign countries in which French measures are in vogue. The same difficulty surrounds the measurement of the power of motors. The unit of power is, indeed, from the nature of the case, common to the whole world—it is unit of weight multiplied by unit of height,—and with us the foot-pound, or 33,000 times the foot-pound, is generally accepted; but the difficulty lies in determining how the measure is to be applied. Thus, in the case of a water-motor—should the power be calculated by the energy latent in the falling water, or in the actual work given off by the motor? In heat engines we have to deal with many variables. There is the initial pressure of the working agent, the terminal pressure, the length of stroke, the number of revolutions per minute, the indicated power in the cylinder, the effective power given off, and the adequacy of the means of supplying the working agent. In the early days of steam, when pressures were pretty uniform, and speed bore a certain relation to the stroke, the diameter of a cylinder was a tolerably close index to the power of the engine, and such simple rules as '10 circular inches to the horse-power,' which prevailed among agricultural engineers, were tolerably intelligible. But in these days, when pressures, speeds, and rates of expansion vary so greatly, the size of the cylinder, or cylinders, is no longer a guide, and I imagine that most manufacturers have ceased to class their engines by their nominal horse-power. The problem is pretty simple in the case of pumping engines, for there the nominal power may be taken, as it is in Holland, to be the actual work performed upon the water, and perhaps a similar rule might apply to motors driving dynamos, but for most other purposes no simple law is possible. In my own practice I have, for many years, been in the habit of classing engines by the indicated horse-power per one revolution for every probable initial pressure, below the maximum one for which the engines were designed, and for various rates of expansion. To facilitate the calculations I use curves which give the theoretical horse-power, on the supposition that steam expands according to Boyle's law, for 10,000 cubic inches of steam measured at the moment of exhaust, which is, in fact, the volume of the cylinder in single-cylinder engines, and the volume of the last cylinder in compounds. These curves are calculated for initial pressures rising by 25 lbs., and, in non-condensing engines, for the extreme range of expansion possible, and to fourteen expansions in condensing engines. The true indicated horse-power ranges from 80 per cent. to 85 per cent. of the theoretical, as above stated, the precise percentage depending upon the construction of the engine. As large engines are now almost always compound, the size of the cylinders is no guide to the lay mind; hence, in answering inquiries, it is necessary by some means to get at the actual

horse-power expected and to settle the initial pressure, for on this point there is still much timidity among steam users, so that the engine builder has to adapt himself in this, and other particulars, to the needs or prejudices of his customer.

In marine engines, again, the difficulty is still greater, because the only measure of the effective power of the engines is the speed of the ship under given conditions of immersion. But the resistance of ships is a complicated matter, not perfectly ascertained yet, so that the speed attained in any new combination of engines and hull is by no means a certainty; hence some recognised measure of the power of a marine engine, depending only on the measurement of the cylinders and boilers, becomes very desirable.

So strongly has the want of a standard horse-power been felt by shipbuilders and marine engine makers that the council of the North-East Coast Institution of Engineers and Shipbuilders appointed a Committee to investigate the subject, and to devise, if possible, a set of rules which would be generally acceptable. The Committee made its report in the spring of 1888. They took as their basis the Indicated Horse-Power, under certain normal conditions, and propose to call this the Normal Indicated Horse-Power (N. I. H. P.). The normal conditions are, briefly, the following:—

1. That the steam, of whatever boiler-pressure, is expanded to the same terminal pressure.

2. That the expansion is effected by all engines with the same degree of efficiency.

3. That the piston speeds of engines of different lengths of stroke are proportional to the cube root of their respective strokes, and, further, that the actual loaded trial-trip value of piston-speed may be taken as 144 times the cube root of the stroke in inches ($144\sqrt[3]{S''}$).

4. That in cases in which the engines and boilers bear to each other such proportions as to prevent condition 1 from being fulfilled without thereby violating condition 3, the coal consumption per I. H. P. will not be affected, but will be constant for the same boiler-pressure.

5. That the boilers are constructed in accordance with what will be generally recognised as the average practice of the present day in respect of the allowance of steam room in relation to power, the diameter, area, and pitch of tubes, the relation of grate to heating surface, and the area of uptakes and funnel; that average natural chimney-draught is used, or, if forced draught be employed, that it does not exceed the natural draught; that the horse-power is proportional to the heating surface (H.) and to the cube root of the pressure ($\sqrt[3]{P}$.); and, further, that the actual loaded trial-trip horse-power may be taken as equal to one-sixteenth of the heating surface multiplied by the cube root of the pressure $\frac{(H\sqrt[3]{P})}{16}$.

6. That the efficiency of the engine mechanism is constant, and that the propeller is such as to secure that the engines will utilise the boiler power referred to in condition 5 in the manner prescribed by conditions 3 and 4.

Subject to these conditions the normal indicated horse-power is found by multiplying the square of the diameter of the low-pressure cylinder in inches by the cube root of the stroke in inches, adding to the product three times the heating surface of the boiler in square feet, multiplying the sum by the cube root of the pressure, and dividing the product by 100.

$$\text{N. I. H. P.} = \frac{(D^2\sqrt[3]{S} + 3H)\sqrt[3]{P}}{100}.$$

It is evident from this formula, and from the conditions, that account is taken of all the variables, and that the boiler is regarded as an integral part of the engine. The report gives several useful formulæ deduced from the above. Whether the expressions given are the most convenient possible for general marine practice or not I am not competent to say, but it seems to me that a step has been taken in the right direction in the attempt which has been made to measure marine engines by some rational standard. The members of the Committee were all

thoroughly practical as well as scientific men; they determined their constants by reference to a large number of successful cases; and I sincerely hope that the question will be pursued by the marine-engine builders on the West Coast, and by the constructors of land engines. As engineer to the Royal Agricultural Society I have frequently had to define the power of engines entered for competition for the Society's prizes, and I have experienced the greatest difficulty in laying down rules for the guidance of intending competitors, being fearful, on the one hand, of restricting originality, and, on the other, of admitting engines of greatly varying powers.

I have expressed an opinion that the numerous engineering societies which exist at this day have it in their power to promote the advancement of mechanical science in a notable manner by appointing research committees, or by aiding individual investigations from their abundant means. The North-East Coast Institution of Engineers and Shipbuilders has done good service in their endeavours to establish a practical measure of the power of marine engines, while the Institution of Mechanical Engineers has, for the last ten years, been steadily promoting researches of an eminently practical nature. Their expenditure has reached the handsome sum of 1,700*l.*, and their proceedings have been enriched with reports on the 'Hardening, Tempering, and Annealing of Steel,' on the 'Form of Riveted Joints,' on 'Friction at High Velocities,' on 'Marine Engine Trials,' and on the 'Value of the Steam Jacket.' The names of those who are acting on these Committees are a guarantee that the investigations conducted by them will rank among the classical works of the profession, and will abundantly justify the liberal expenditure which has been incurred.

It is impossible to conclude the address which I have had the honour of delivering without an allusion to the most important structure which engineering skill and enterprise has ever attempted. The Forth Bridge is rapidly approaching completion, and on Saturday, September 14, Mr. Baker is to deliver a lecture, in which he will, no doubt, tell us when the great work is likely to be completed. I think that the members of this Section belong sufficiently to the 'working classes' to have a claim to admission to the lecture, and to hear from the lips of the creator of the bridge the story of its inception, of its progress, and his hopes as to its completion.

The following Papers were read:—

1. *Experiments upon the Transmission of Power by Compressed Air (Popp's System).* *By* Professor A. B. W. KENNEDY, *F.R.S.*, *M.Inst.C.E.*— See Reports, p. 448.

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2. *Water-gas in the United States.* *By* ALEX. C. HUMPHREYS, *M.E.*

Water-gas is generally obtained by the decomposition of steam which has been brought into contact with incandescent carbon.

The first reaction that occurs is the formation of carbonic acid and the liberation of hydrogen. The carbonic acid is brought into contact with an additional quantity of incandescent carbon, from which it takes up an equivalent and becomes carbonic oxide, so that there results, theoretically, a mixture of hydrogen and carbonic oxide in equal volumes. These gases have no light-giving properties, so that if they are to be used for illuminating purposes, they have either to be mixed with some hydrocarbon in the gaseous form, or they must be employed to raise to a white heat some solid substance, such as lime, magnesia, salts of zirconium, lanthanum, or platinum, &c.

There are two ways of effecting the decomposition of steam: one is intermittent, the other continuous. In the first a furnace of the cupola pattern is used, the fuel is raised to the desired temperature by a blast of air, which is shut off as soon as this temperature is attained and steam is turned on, the blowing up and the injection of steam succeeding one another intermittently. In the continuous process the carbon is either placed in retorts heated externally and steam passed through

uninterruptedly, or a cupola furnace is employed, and steam and air are forced in continuously, but the latter process has the disadvantage of the resultant gases being associated with a great deal of nitrogen, so that after enrichment with hydrocarbons the flame is 'tender,' it is easily blown out, and smokes on small provocation.

The author stated that Fontana first proposed the manufacture of water-gas in 1780, and he traced the history of the invention through its successive stages of improvement to the present day; he enumerated the large number of patents, which amount in the aggregate to 100, that have been taken out since 1823; he summarised the merits and defects of each, and closed his sketch by alluding to the battles fought in the United States between the coal-gas and the water-gas interests, the question of the danger of the latter being the main point at issue. The professional papers ranged themselves on opposite sides, and courts of law had to decide between the conflicting evidence of experts. The old Boston Gas Company succeeded in obtaining the passage of a law prohibiting, in the State of Massachusetts, the manufacture and sale of gas containing more than 10 per cent. of carbonic oxide, this rendered it impossible to manufacture water-gas economically. Litigation of an energetic character went on for years, and, indeed, is still raging, though 223 Boston doctors have signed their names to a declaration 'that water-gas is no more dangerous to health and life than coal-gas, and there is no just ground, so far as health and life are concerned, to prohibit its manufacture.' This opinion has been endorsed by numerous chemists of eminence, both in the United States and in Europe.

In 1874 there was practically no water-gas made in the United States or in Canada. It is estimated that at the present day, out of 1,150 gasworks, 300 are on the water-gas system.

With the quantity of gas produced the quality has improved greatly, so that there is now probably no gas better adapted for distribution in extremely cold climates than a water-gas made in a modern plant of certain construction, and that, too, from ordinary furnace coal, gas coke, and crude oil.

The author next proceeded to consider the theory of the process in detail, and calculated the distribution of heat throughout the reactions, remarking that it is only by the application of the water-gas system of manufacture that the whole of the carbon used can be converted into gas.

The following details are included in most of the plants constructed on the intermittent system. An upright furnace of the cupola type is used both for combustion and for gasification. This is called the 'generator,' or 'gasogene,' to supply which steam is generated in an independent boiler, and the steam is sometimes superheated either by the fire of the regenerator, or by waste heat.

In one class of apparatus the generator is provided with two outlets, one of which is connected to the chimney, and the other to the wash-box, or hydraulic seal, both outlets being controlled by valves. In another class the generator is connected to a separate superheater, or fixing chamber, which is provided with the two outlets, as described above. The fixing chamber is filled with refractory material, and is intended to store up heat during the 'blows,' which heat is to be used in the 'run' for fixing or rendering permanent the hydrocarbon gases added to the water-gas. In both cases the gas is condensed, scrubbed, purified, and measured in the same way as ordinary coal-gas.

In the 'Tessie de Motay' or 'Municipal' process the products of combustion and heat during the 'blows' are lost up the chimney. The water-gas goes to a crude-gas holder, from which it is passed to the carburetters, which consist of a number of shallow pans, containing naphtha, over the surface of which the gas passes, the temperature being carefully regulated. The mechanical mixture of gas and naphtha vapour is then fixed by being passed through retorts arranged in benches and sometimes fitted with baflers. Means are provided for easily testing the gas, which can be produced of a very even and beautiful quality. This process, though wasteful, has met with marked success for several reasons, which were given.

The 'Wilkinson' process is similar to the one just described, the chief point of difference being the admission of steam to the generator alternately, upwards and

downwards through the fuel, the object being to prevent that near the grate bars from becoming too dead and so escaping conversion.

The 'Jermanofski' system is similar to the Wilkinson, but a fixing chamber filled with limestone is added, and it is claimed that some benefit is derived from the arrangement, though the author has not been able to determine what it is, except that a certain amount of carburetting is done in it.

In the 'Meeze' process the water-gas is also made independently, but the carburetting is performed in clay retorts, fitted with an internal, central, perforated iron pipe, through which the oil and gas enter, or, the author believes, that the oil only is now admitted, and its vapour mixes afterwards with the gas in the hydraulic main.

The 'Lowe' process is typical of the 'generator-superheater' class, and its value may be judged from the number of patents that have been grafted on it, mostly with a view to evasion, but a recent judicial decision has thoroughly established the rights of the original inventor.

The 'Granger-Collins' process originated directly in the Lowe, where the generator and superheater, were connected by an iron pipe which acted ingeniously as a cooler. Messrs. Granger and Co. shortened this connection and lined it with fire-brick, but finally suppressed it altogether by making the superheater partly overlap the generator, and thus secured direct communication without sacrificing the facilities of stoking from above. The oil, also, was introduced by an injector or sprayer, so that it met the water-gas coming over from the regenerator. Messrs. Granger and Co. were the first, or among the first, builders of water-gas plant to appreciate the necessity of making the superheater of ample size, and their installations have achieved a deserved popularity.

The 'Springer' apparatus, constructed by the National Gas Light and Fuel Company, of Chicago, encloses the generator and superheater in one shell, the two chambers being separated by a firebrick arch, the fuel being introduced into the lower by lateral furnace doors. The combined generator and superheater attains to a very large size, more than 12 feet diameter by 50 feet high, with a producing capacity of one million cubic feet per twenty-four hours. The steam in this plant can also be passed up or down through the fuel, and the oil is introduced either at the bottom or the top of the superheater, by means of a steam injector.

The 'McKay-Critchlow' apparatus is similar to the Springer, but is especially designed for use with natural gas, which is introduced under the grate bars with the steam. It becomes split up and carburets the manufactured gas. Natural gas alone has feeble and irregular illuminating power, and is very flabby and unsteady.

The 'Flannery' apparatus and the 'Hanlon-Teadley' do not differ essentially from the types which have been described already, and it is doubtful whether the alleged improvements have any substantial advantages. The last named has been introduced into Philadelphia on a very large scale, and professes to supply gas at the rate of 37 cents per thousand cubic feet.

The 'Lowe' process is now in the hands of the United Gas Improvement Company of Philadelphia, who are the largest manufacturers and owners of gas plant in the States. The apparatus, as may be gathered from what has been already said, has undergone many modifications at the hands of licensees; especial attention has been directed to the manner of supplying the oil, which has increased in importance since the serious rise in the price of naphtha has driven the gas-makers to resort to crude oil. The United Gas Improvement Company now always heats the oil before introducing it into the generator, and this is done by preference at the expense of the waste heat in the gas passing from the superheater, but precautions have to be taken for preventing the formation of lamp-black inside the pipes, or for removing it when formed, and with this view several varieties of heaters are in use. The oil is pumped from a measuring tank through the heater and introduced into the generator through four fire-clay pipes which pass obliquely through the arch forming its top, and are arranged to slide back during the time that the 'blowing-up' is in action. The author devoted a considerable space to discussing the details of working, and pointed out very clearly what are the conditions to be observed in order to ensure the most advantageous results.

Tables were given showing the chemical composition of the gas, as well as its thermal and physical properties, and a great deal of information was afforded as to the cost of production both in materials and labour. The author next discussed the manufacture of non-illuminant gas, and mentioned that not much progress has been made in its use in the States, where its inodorous character has proved a source of danger. He gave tables of analysis which exhibited the composition and properties of the gas.

By the 'Evans' process the coke from ordinary coal-gas retorts is raked by hand into a generator set underneath, and converted into water-gas by the usual method, but without being carburetted.

By the 'Loomis' process bituminous coal is treated directly in a generator, the air for combustion being drawn down through the fuel instead of being driven up. Two kinds of gas are produced and stored separately: ordinary producer-gas during the ignition period, then water-gas and hydro-carbon vapours given off during the gas-making period. A new process, patented by Walton Clark, is in course of trial by the United Gas Improvement Company. Bituminous coal is charged by gravity into inclined retorts, which are heated by the combustion of the blast gases from the generators in which the water-gas is made. The coke, after distillation, falls by gravity into the generator, where it is subjected alternately to an air-blast and to steam. When the air-blast is on, the products of combustion pass through a flue into the retort benches where they are burned and provide the heat necessary to distil the coal. When steam is injected into the generator the water-gas produced passes through the retorts, and so to the hydraulic main. There being two generators and two retort settings in the system there is a continuous flow of producer-gas to the ovens, and of water-gas into the mains. The two benches of retorts are expected to yield 400,000 cubic feet of gas per 24 hours, with a calorific value of from 400 to 450 units per cubic foot, and to obtain a yield of 45,000 cubic feet to the ton of coal. This practically non-luminous gas can, of course, be carburetted at a cost of from $3\frac{1}{4}$ to $3\frac{3}{4}$ gallons of low grade oil per 1,000 cubic feet.

The author pointed out the importance of the system above described to this country, because it enables soft bituminous coal to be used instead of anthracite, which is found but in small quantities here, and he concluded thus: 'In closing, it may not be amiss to give expression to the belief that the day of gas—fuel-gas—is rapidly approaching, and, as has been before pointed out, fuel-gas must mean, in part, water-gas. Even the great rival of gas, the electric light, may yet be dependent upon it for the cheapest means of producing the electric current. Then will the gas engineer and the electrical engineer, shoulder to shoulder, be striving to correct the present wasteful strains upon nature's storehouses.'

FRIDAY, SEPTEMBER 13.

The following Papers were read:—

1. *An Apparatus for providing a Steady Platform for Guns, Search Lights, Telescopes, &c.*[1] *By* BEAUCHAMP TOWER.

The author described an apparatus large enough to carry a 3-pounder gun, which he has constructed and mounted on a 25-ton steam yacht, and which keeps perfectly steady even when the vessel is rolling and pitching violently.

The paper was illustrated by three diagrams.

The apparatus consists of the platform, which is the part to be kept steady, and which is hung in gymbals. The steadying forces are applied by four cylinders attached to the platform, which push by means of rams at four external points.

[1] Substantially identical with the paper read before the Institution of Naval Architects on April 12, 1889, and published in their Transactions.

The action of these cylinders is controlled by a wheel revolving rapidly in a horizontal plane on a ball and socket bearing attached to and between the four cylinders. Water at 100 lbs. pressure is pumped by a pumping-engine through the gymbals, which are made hollow for the purpose, and thence through a pipe on the platform to the ball and socket bearing of the wheel, which has a passage through it for the water to pass to a cavity in the centre of the wheel; from this cavity some of the water passes to tangential jets, which cause the wheel to revolve by their reaction at about 1,500 revolutions per minute. The remainder of the water issues from an axial jet which projects upwards from the wheel, and has opposite to it, and at a distance about equal to the jet's diameter, four ports grouped close together, and each connected by a passage to one of the four cylinders.

The wheel, being hung a small distance above its centre of gravity, settles itself down to revolve in a truly horizontal plane, and to throw a truly vertical jet out of the axial nozzle. This jet striking on the four ports causes a water-pressure in the four cylinders, which pressure is equal in all the cylinders if the jet is truly concentric with the four ports; but, if it is not, one of the ports receives more of the jet than the others, and the cylinder connected to it has a greater pressure, and consequently pushes harder than the others, and pushes the platform over till the ports and axial jet are concentric. The axial jet thus forcibly compels the platform to be co-axial with it. The object and advantage of this arrangement is, that while the wheel acts powerfully on the platform it suffers no reaction on itself, and no matter what disturbing forces are brought to bear on the platform none of them can affect the wheel.

The wheel, revolving in a horizontal plane, and hung a short distance above its centre of gravity, is in reality a long-period conical pendulum having a period of about 90 seconds, and is analogous to Mr. Froude's wheel which he used for recording the rolling of ships. This was a pendulum whose period was longer than that of the waves, so that it might be undisturbed by the wave forces. The author has experimented with this apparatus at sea for a considerable time, and has overcome the usual practical difficulties and brought the apparatus to a high state of perfection.

The apparatus is also applicable for controlling swinging-cabins, and experience with it seems to justify the belief that the abolition of the angular movement alone would prove a great mitigation of sea-sickness.

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2. *On the Vibration of Railway Trains. By* Professor JOHN MILNE, *F.R.S.* —See Section A, p. 492.

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3. *Machinery for the Manufacture of Bottles.*[1] *By* H. M. ASHLEY.

The author explained the various manipulations of glass in the old or mouth-blowing process, viz.:—Gathering, marvering, blowing of the bulb, completing the parison, blowing in the mould, wetting off, warming in or flashing, lapping of the ring, and finishing the ring with the tools; and he showed how the gatherer gives quantity and solidity or plainness to the bottle; the blower equal distribution of the glass, and the final shape of the body; the wetter-off separates the bottle from the pipe, though in so doing he crizzles the neck, which the 'Maker,' as he is called, repairs by flashing, and then laps and finishes the ring. He said that it was a difficult matter to get a perfect weld of neck and ring by this plan, as is proved by the crizzles so often seen under the ring.

He then proceeded to explain some of the characteristics of bottle-glass under varying conditions, showing that at its normal temperature it is a very slow conductor of heat, but at 3,500° F. a very rapid conductor; and that if brought into contact with a metallic surface will instantly impart much of its heat, both external and internal, to it. He also showed that the temperature of glass can be

[1] Printed *in extenso* in *Engineering* for October, 1889.

gauged to the greatest nicety by its varying colours, and that it can be fluid, plastic, elastic, and brittle, in the space of five minutes. That at 3,500° F., or pale chrome tint, it is well adapted to be cast in heated moulds; at 2,000°, or orange tint, to be moulded with tools; at 1,000°, or red tint, it is elastic, and almost undamageable; and at less than 100°, or green tint, it is quite brittle.

The author then proceeded to describe his invention, which is based upon the foregoing characteristics or qualities of glass, and showed first, that a bottle made by his process is absolutely homogeneous, being made by casting, then punching, and then blowing. The casting giving the primary external shape to ring, neck, and body; the punching giving the internal shape of neck; and the blowing completing the bottle after the bottom has been flattened with the paddling tool; and he illustrated his remarks by showing bottles in various stages of manufacture, together with diagrams of the same, and also of the parts of the machine by which they had been made.

Mr. Fairley, Borough Analyst of Leeds, has tested eight bottles sent to him for the purpose with his hydraulic tester, up to a maximum of 400 lbs. per square inch, internal pressure, and not one of them gave way, and this enormous strength is explained as the result of the casting of the bottle, at a temperature of 3,500°, which allowed the molecules to flow by gravitation, and so to adjust themselves in the mould as to make distortion or crushing impossible.

It was also shown that not only was the new process a very great saving to the manufacturers, as one boy can make three bottles per minute with the machine, but also that it is a very easy and healthful occupation; whereas bottle-blowers by the old process only attain an average age of thirty years.

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4. *The Utilisation of Fibrous Peat for the Manufacture of Brown Paper, Wrappers, and Millboards.*[1] *By* J. A. London.

The author said his object was to show the practical uses of suitable peat fibre as a raw material in the manufacture of brown paper, wrappers, and millboards, and its economical use in many ways.

The machine the writer uses for treating this material is a 'Willow' or 'Devil,' consisting of one drum 3 ft. diameter by 12 inches on the face. This drum is covered with a concave. Both the drum and concave are furnished with cone-shaped teeth, so that the fibre cannot adhere to the teeth; but the principal advantage is that the teeth can be set to fibreise to any degree of fineness. Owing to the speed at which it runs, no fibre hangs about the machine, and it will fibreise or tear the peat fibre in a wet or dry state.

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5. *Hydraulic Apparatus for Railway Signalling.* *By* C. E. Carr.

The object of the apparatus, as described by the author, is to combine in *one* lever the operations of moving a pair of switches and the protecting signals.

The points are actuated by a double-acting piston in a small cylinder placed at a convenient distance from the rails; the signals by single-acting pistons similarly placed, the arms being weighted as in the ordinary arrangement and flying to danger as soon as released.

The motive power, generated in a convenient place and stored in an accumulator placed near the signal-hut, is conveyed to the actuating pistons by a pipe; the valves governing the pressure are connected by rods to the actuating lever in the signal-box.

This lever works in a quadrant furnished with notches, and is secured in any desired position by a detent. The normal position of the lever is upright, and it can be moved in either direction.

Taking as an example an ordinary cross-over road, if the handle is moved to the right and placed in the first notch, the locking bars would first be moved so as

[1] See *Newcastle Daily Chronicle*, September 14, 1889.

to unlock the points, the points themselves then pulled over and relocked; the second notch would perform a similar series of operations at the other pair of points in the cross-over road; the third notch would lower the home and the fourth the distant signal. In the present system of signal apparatus, six levers would be required to work this operation, and eight distinct movements would have to be made: unlocking each pair of points, moving them, relocking them and then working the two signals. The same lever, if moved to the left, would perform a similar series of operations for a train passing in the opposite direction. The valve rods are so interlocked that if from any accidental cause the points are not pulled fully over, the signals cannot be lowered.

SATURDAY, SEPTEMBER 14.

The following Reports and Papers were read:—

1. *Report on the Investigation of the Action of Waves and Currents on the Beds and Foreshores of Estuaries by means of Working Models.*—See Reports, p. 327.

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2. *Report on the Development of Graphic Methods in Mechanical Science.*—See Reports, p. 322.

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3. *Ships for the Carriage of Petroleum. By* A. R. LIDDELL.

The petroleum ship industry began on the Tyne about five years ago, when the steamship 'Glückauf' was built by Sir W. G. Armstrong, Mitchell & Co. for Herr Riedemann of Bremerhaven. Some early ships—the 'Vaderland,' 'Nederland,' and 'Switzerland'—were built by Messrs. Palmer & Co., of Jarrow, in 1872 to carry petroleum in bulk, but they were never employed in the trade. Prior to 1886 some ordinary cargo vessels underwent costly alterations, and were converted into petroleum carriers, but were only partially successful. American petroleum has a specific gravity of ·8. It varies with the temperature to the amount of about 2 per cent. for a difference of 40° F., and it gives off a vapour which is very inflammable. Petroleum was at first carried in wooden sailing-ships, in barrels or boxes in the hold; but under these systems a much smaller amount of cargo could be carried, and the barrels and boxes were very costly. The later petroleum steamers are commonly spar-decked, and range from 250 to 300 feet in length, and from 1,500 to 2,500 tons gross register. They have their machinery aft, oil-holds up to the main deck, and a long trunk from 10 to 15 feet wide from the main to the spar deck. The latter acts as a feeder, and allows the oil to expand and contract within it without dangerously affecting the vessel's stability. To have the holds half full, with the oil free to wash about, reduces the ship's righting moment, and special care has to be taken in loading and discharging. Water ballast tanks are commonly fitted, and a peculiar saddle-shaped tank, patented by Mr. H. F. Swan, has been found specially useful. The oil-hold is divided into compartments by a centre line bulkhead and by transverse bulkheads about 20 feet apart, and the ordinary structural details are modified in many respects on account of the greater difficulties attending oil-tight work. The surveyors of Bureau Veritas have done very much to help forward this industry, while their rivals of Lloyd's Register have remained comparatively inactive. These vessels are all supplied with powerful pumps, and have large oil and water mains led along the main deck, with branches into the holds and connections to meet pipes from the shore. The oil is pumped into large reservoirs at the port of discharge. A cargo may consist of several qualities of oil, and these are separated from each other by narrow water-spaces. The sailing-ship 'Hamaut' was built about two years since

by the Barrow Shipbuilding Co. for Messrs. Stephen Speth & Co., of Antwerp, to carry petroleum in bulk in competition with the steamers, and proved successful; and it is suggested that the example might be advantageously followed by others. Petroleum vessels cannot be used for other purposes, on account of their peculiar arrangement and smell. A proposal to carry palm oil in a similar manner has hitherto been found impracticable on account of corrosive ingredients, which attack the steel in place of preserving it as petroleum does. Electric lighting is resorted to to lessen the danger of fire. The petroleum industry is expected to increase in the future, and it is hoped that the Persian and Arabian deposits of oil may before long be worked.

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4. *The Corrosion and Fouling of Ships and Antifouling Compositions.*[1] *By* M. Holzapfel.

After referring to the work published in 1867 by Charles F. T. Young, dealing with different trials made by the British and French Admiralties and others, and to the paper at this year's meeting of the Institute of Naval Architects by Professor Lewes, the author states that to obtain a successful antifouling composition the action of copper and yellow metal should be imitated as closely as possible.

In the times of the wooden sailing-vessels copper or yellow-metal sheathing was employed with very good results, and it still is so employed, lasting under ordinary circumstances for three or four years, and keeping vessels clean for that period. When iron vessels were first introduced, sheathing with yellow metal, zinc plates, and other metallic compounds was tried, but all failed. Many compositions were then brought into the market, but when practically tested they were found to be inadequate, lasting barely six months.

What the Government and private shipowners then aimed at was a composition to last as long as copper sheathing on wooden vessels. The building of dry docks, however, at all the important ports in the world, and the rapidity with which vessels are now cleaned and painted, have made it unnecessary for a composition to last for such a period, particularly as it is now always considered advisable to dock vessels every twelve months.

A composition which will keep a vessel clean for twelve months in ordinary trades is at present likely to meet with the best success. It must, however, comply with the following conditions:—

1st. It must absolutely protect the ship against rust.

2ndly. It must have a very smooth surface, so as to reduce surface friction to a minimum.

3rdly. It must be quick-drying.

As to antifouling properties, there are two methods by which they are supposed to be obtained:—

1st, exfoliation, *i.e.*, the separating of small particles of the composition from the main body, by which any animal or vegetable growth which may have attached itself is caused to drop off the bottom of the vessel; and, 2ndly, poisoning, by which the fouling matter is supposed to be killed either before attaching itself or after.

Some lean to the former principle, others to the latter. Mr. Young attributes the antifouling properties of copper and zinc sheathing to exfoliation only, and Professor Lewes, without saying so distinctly, leans strongly in that direction. Both, in the author's opinion, are wrong; for it is from the fact that copper and yellow metal *only poison when they exfoliate* that they become antifouling, and it is only metals and compositions which in exfoliating produce poisons that are effective antifoulers.

After adducing several facts in support of his theory at length, and quoting the poisons mostly employed by antifouling composition manufacturers of the present day, he concludes by saying that any improvements in the immediate future in composition can only be effected by a perfect adjustment of the various

[1] Printed *in extenso* in the *Shipping and Mercantile Gazette*, September 17, 1889, and the *Steamship*, October 1, 1889.

gums used in the preparation of the varnishes employed in the manufacture of antifouling compositions with the various antifouling materials employed, so that the composition may be quite reliable even in cases where the paints now used sometimes fail to fully answer their purpose.

MONDAY, SEPTEMBER 16.

The following Papers were read:—

1. *The Distribution of Electricity from Accumulators.*[1] *By* Major-General WEBBER.

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2. *Precautions to be adopted when the Electric Light is supplied by means of Transformers.*[2] *By* KILLINGWORTH HEDGES, *M.Inst.C.E.*

In a paper entitled 'The Fire Risks of Electric Lighting,' which was read at the Southport meeting of the British Association in 1883, the author urged, he believes for the first time in this country, the necessity of regulations and the adoption of proper safety appliances. The fire insurance companies have universally recognised the importance of having the leads in the houses thoroughly insulated and protected by cut-outs, and the rules which have been published by the Institution of Electrical Engineers, and by some of the leading fire insurance offices, have been so far successful that no fire of any magnitude has been caused by the electric light.

In this paper the author treats of a new danger which may occur when transformers are employed to convert currents of high tension into the pressure suitable for the incandescent lamps. The danger of fire may be obviated by thorough insulation, but should an alternating current of 1,000 volts or more break through the transformer into the house circuit, a dangerous shock might be taken by anyone inadvertently touching the lampholder or some unprotected part of the circuit, if any portion of his body was in connection with a wire of opposite polarity, or in some instances with the earth. Such an accident might possibly occur, although the lamps would give no indication that the electro-motive force was more than normal.

The conditions which would cause such an effect are stated, and the precaution necessary is either to earth the secondary circuit, which has, however, certain disadvantages, or to connect one or both of the leads to a safety appliance which would automatically divert any excess current to earth, and at the same time shut off the supply in that portion of the faulty circuit by the fusion of the lead wire or mica-foils in the main cut-outs.

The Cardew static arrangement, which has been adopted experimentally by the London Electric Supply Company, and the vacuum protector designed by the author, both effectually prevent any leakage from the primary to the secondary circuit. Numerous experiments have been made with the last apparatus to ascertain the distance which an alternating current of high E.M.F. will leap across the two electrodes which were fixed in the opposite ends of a glass tube from which the air has been partially excluded. The results differed considerably from those given by De la Rue in his experiments with a continuous current, and a phenomenon was noticed, that the arc after starting between the two points almost invariably extended itself to a bow shape and ran back to the base of one or both of the platinum electrodes, one of which nearly always fused, leaving that opposite intact.

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[1] Printed *in extenso* in the *Electrician*, vol. xxiii. p. 577.

[2] Published *in extenso* in the *Electrical Review*, September 20, 1889.

3. *The Design of Transformers.*[1] *By* J. SWINBURNE.

The present practice in designing transformers is to use a continuous or closed circuit for the core, and to make this core very large in cross-section, so that the excitation needed to produce the desired induction is small. The tendency is, in fact, to increase the quantity of iron in a transformer, and to decrease the copper.

The excitation in a closed circuit transformer is a matter of little importance, but the loss of power by hysteresis may be, and often is, very serious, especially when it is remembered that transformers used in houses have their full load on only very occasionally, while the loss by reversal is going on continuously. The author has calculated tables showing the best forms that can be given to closed circuit transformers for various loads, the loads being on for different numbers of hours per day. These tables show that, even for cases where the full load is always on, the cores should be smaller than is now usual; and that for most house work, when the transformer is only at times partially loaded, the cores ought to be exceedingly small to give a high efficiency, and that the high efficiency is accompanied by excessive variation of secondary electro-motive force and high cost.

Open circuit transformers of the type introduced by the author can be made, in which even the full-load efficiency is higher than can be got with a closed circuit, while the very low average efficiency of house-transformers can be remedied without great variations of secondary pressure or heavy cost.

The author's transformer is of the Ruhmkorff coil type, but has the core brought out past the ends of the copper coils, and the wires spread out into a sort of thistle-head or hedgehog. The induction is not great at any region in the air, and the magnetising current is not large enough to balance the advantage of the small volume of iron needed.

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4. *Electric Launches on the Thames.*[2] *By* G. FORBES, *F.R.S.*

This paper has arisen out of the fact that during the past summer, while the author was living on the banks of the Thames, he took the opportunity to keep one of the electric launches which have lately been built by Mr. Tagg and electrically equipped by Messrs. Immisch. There are certain peculiarities about the Thames which render the wants of a launch-owner somewhat different from what they may be on other waters. The author thinks it well to make known his experiences, in order to hasten what he considers must be an accomplished fact ere many years, viz., the extinguishing of pleasure steam launches from the river Thames owing to the survival of the fittest.

Among the points worthy of notice are that launches are chiefly wanted in summer, when the heat and smoke, smell, oil, and dirt of a steam launch are objectionable, and that owing to the large traffic, and to prevent injury to the banks and boats on the banks it is impossible to allow high speeds in launches; hence, a comparatively small supply of accumulators or storage batteries is required. It may also be added that on the Thames it is easy to secure a sufficient number of charging stations. At present there are four or five at easy distances apart. Eventually the hotels on the river will be lighted electrically, and this power can be used for charging the storage batteries on launches. The author's house was at Bray, and each night after dinner he sent the launch or took it up, towing a boat for the return journey, to a charging station a mile away, just above Boulter's Lock. At breakfast time the 'Delta' was always found moored in front of the house. A start was generally made after breakfast, and on returning to dinner at 8 P.M. the charge was never exhausted. The boat could be easily managed by a lady, even when entering and leaving crowded locks.

The 'Delta' is 33 feet in length, and has a beam of 6 feet, her draught is 15 inches forward and 18 inches at the stern. She is fitted with 44 cells, weighing in all 2,520 lbs. She is steered by a wheel in front within reach of the three handles

[1] Printed *in extenso* in the *Electrical Review* for September 20, 1889.
[2] See *Electrician*, vol. xxiii. p. 504.

required for working her. The first of these is to put the current on or off; the second for half or full speed; the third for going ahead or astern. The first is mechanically locked with the others, so that they cannot be moved without first cutting off the current. Fusible cut-outs are inserted in the circuit, so that if the propeller become jammed by weeds the motor will not be burnt up. The speed of revolution of the motor, which is coupled direct to the propeller, is 720 revolutions per minute for full speed and 510 for half speed. The full speed is only between five and six miles an hour. This is really fast enough for ordinary work; it is only where there is a strong stream that it is sometimes a little tedious creeping up for half an hour. The speed might be increased by putting in more accumulators, which the launch could easily carry under the floor without overloading. At present the batteries are all under the seats on each side of the boat. Thus the whole space is clear for passengers, of which she could easily carry twenty. It is clear that the electric launch has a great advantage over the steam launch. If we reckon the size of launch by the number of passengers it will hold, the electric launch is the cheaper.

The author spent one day in testing the performance of the launch on a trip of nearly 30 miles. Starting from the house at Bray at 11.45 A.M. the time was taken, and allowance made for all the locks passed through and other stoppages. At 4.1 P.M., near Hambledon Lock, the return journey was commenced, and, stopping an hour at Medmenham Abbey, home was reached at 7.48 P.M. During the outward journey allowance for locks was made by distance. On the return this allowance was estimated by time. Thus on the outward journey the average speed was 1 mile in 11·3 minutes, and on the homeward journey in 10·2 minutes. The average of these is 790 feet per minute. On arrival at home the stern was attached to a spring balance connected by a rope with the shore. The pull at full speed was 97 lbs., which, though not accurately, still approximately gives the pull when the motor is going at the same speed while the launch is going on. This gives 1·44 horse-power or 1,074 watts, including electrical losses, slip, and all friction. The average pressure at the motor terminals during the run was 78 volts, and the average current 23 ampères, which gives 1,794 watts expended. This gives a total efficiency of 60 per cent. This is not at all bad, and promises well for the future.

The author suggested that, in order to supply the enormous demand which will exist after a few years for charging stations, negotiations should be opened with the Thames Conservancy, and also with millowners at the weirs, to establish charging stations with water-power at nearly all the weirs, and thus to establish the most perfect system of pleasure-launching in any part of the world.

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5. *Series Electrical Traction (Northfleet Tramways).* *By* EDWARD MANVILLE, *M.I.E.E.*

The expenses of horsing a tramway form such a serious proportion of the total working expenses that any cheaper effective method of propulsion will naturally be gladly received by the various companies.

Many leading authorities in tramway administration who have tested and considered the various methods of tramcar propulsion have of late publicly expressed their confidence in the great suitability and economy of electricity for the purpose.

It is obvious that, in any systems of mechanical traction requiring the distribution of power over many miles of line, the maximum economy is attained when all the power is developed at one station.

The economical distribution of electrical power over long distances necessarily involves the use of current at high potential, though at the same time it is dangerous to permit large differences of potential at the terminals of motors running in parallel, both in respect of manipulation and the preservation of the motors from injury; but if the motors are run in series these difficulties disappear, and the advantages of high potential are secured.

The extension of the Gravesend, Rosherville, and Northfleet tramways, equipped upon the Series system, was opened in March last.

The salient points of a Series electrical tramway are a dynamo, producing a current of constant quantity—a closed metallic circuit of which travelling motors at all times form a part without ever being short-circuited, or having the current supply cut off from them—the regulation of the power developed by the motor and absorbed by it without interrupting the continuity of the circuit.

The 'Statter' dynamo, used at Northfleet, varies the difference of potential at its terminals from a few volts to upwards of 400, maintaining the current constantly at 50 ampères. This is achieved by an ingeniously-designed electrical regulator, which alters the position of the brushes on the commutator; the pole-pieces of the dynamo being so shaped as to reduce to a negligable quantity the sparking which might be supposed to result from the alteration of the lead of the brushes.

A highly-insulated cable connected to one terminal of the generator traverses the whole length of the line, and is interrupted at distances of 20 feet, the divided ends being connected with the opposite faces of a 'spring-jack,' which is at the same time the automatic switch and contact point.

From the last 'spring-jack' at the far end of the line an uninterrupted cable returns to the other terminal of the generator.

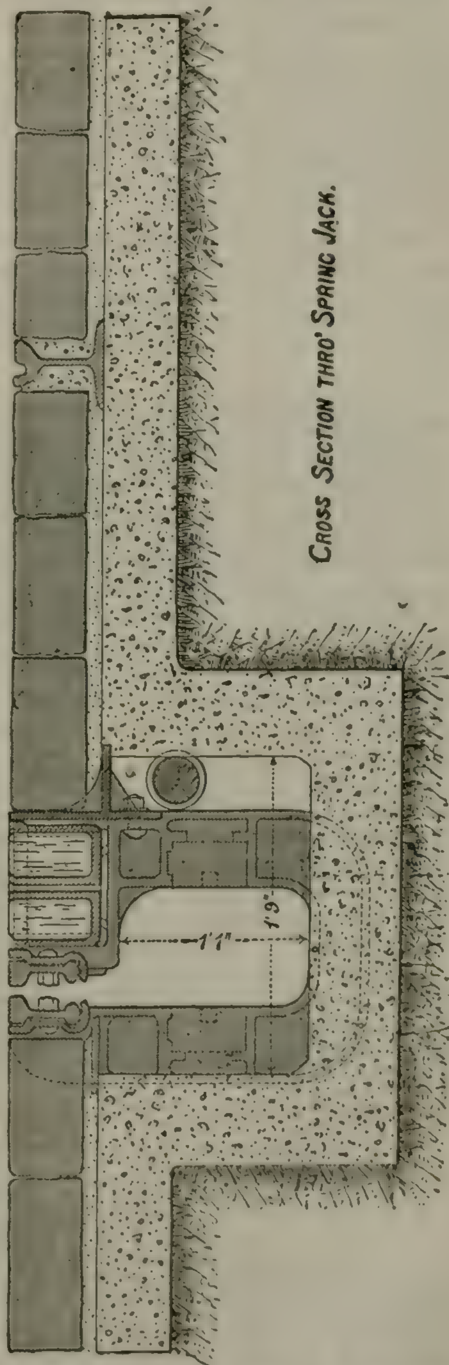
The 'spring-jack' consists of two gunmetal 'cheeks' attached to glazed earthenware blocks by spiral springs, which keep them in contact.

The 'arrow,' or current-collector, which is the same length as and is carried by the car, is so constructed as to pass between the faces of the 'spring-jack' and conduct the current to the motor without at any time short-circuiting it or interrupting the main circuit.

The motors at Northfleet run at 400 revolutions per minute, delivering a maximum of 15 horse-power on the brake, a pinion on the motor-shaft gearing direct with a spur-wheel on the car shaft, with a ratio of 1 to 4½.

A car is lighted electrically by low-resistance Bernstein lamps, running off the terminals of three accumulator cells arranged directly in series with the main circuit.

The generator is driven by a compound Robey engine of 10 horse-power (nominal), the steam being supplied from a locomotive multitubular boiler.



Cross Section thro' Spring Jack.

The conduit through which the 'arrow' or collector travels is arranged directly under one of the running rails. This running rail differs from the ordinary tramway rail, inasmuch as the tread and guard portions consist of two

separate and independent rails having slots seven-eighths of an inch in width between them, through which the mechanical connections between the 'arrow' and the car body pass. The tube is 8 inches in width, the bottom being 13 inches below the surface of the road, this being an exceptionally small conduit as compared with those in use for cable tramways, and, from its position under the side rail, having the further advantage of not needing the two centre rails. These rails are supported by cast-iron yokes, to which they are securely bolted. The yokes are placed at intervals of about 4 feet, excepting at the rail-joints, where they are closer together. The sides and bottom of the tube are formed of Portland cement concrete. At each rail-joint a special chamber is formed, having a convenient removable lid, and in these chambers are placed the 'spring-jacks,' access being obtained to them by lifting the lids of the chambers.

The centre of the tube is placed somewhat inside the break in order that the arrow' shall not be directly underneath the slot, so as to avoid the danger of mud and water from the road-surface falling directly on the 'arrow,' and also on the 'spring-jack' cheeks. The roof of the conduit is formed by a Z-shaped roof-plate. The cable joining the 'spring-jacks' is laid in an independent 3-inch earthenware pipe running from chamber to chamber, and in this pipe also is laid the unbroken return-cable.

The points and crossings are specially constructed to enable them to withstand the weight of the ordinary traffic, a special device supporting the long unsupported projection of the tongue over the conduit, at the same time allowing the mechanical connections between the 'arrow' and the car to pass. The narrowness of a portion of the road required the construction of a length of double-single line—that is to say, with three rails, so that, while keeping the tramcars on the proper side of the road in the direction they are travelling, it makes it impossible for two tramcars to pass each other in this narrow path.

Two of the three rails are laid with conduits, the third being an ordinary tramway rail. The mechanical connections between the 'arrow' and car body consist of five shanks, these shanks being attached to cast-iron shoes or skates which travel on the rail. The skates are connected together by light tie-bars above the rail level, and the whole of the gear is drawn by means of chains attached to the car body.

In series-running, by the employment of a current of constant value it is impossible for the most inexperienced car-driver to damage his motor by either too rapid starting or by reversing whilst running. Indeed, it is a positive advantage in descending a hill to check the speed of the car by altering the field connections so that the armature tends to revolve in the opposite direction to that in which the car is travelling, as the power that would otherwise be lost in braking the car is actually added to that produced by the generator.

This, in large systems with many cars and varying gradients, would appreciably reduce the total power required to be generated, and the consequent consumption of coal. These advantages, combined with the efficiency of distribution as regards the percentage of power lost in the conductors, with, at the same time, a low difference of potential at the terminals of each individual motor, may be regarded as the main advantages of series-running.

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6. *Telephonic Communication between London and Paris.* *By* W. H. PREECE, *F.R.S.*

The practicability of speaking by telephone between London and Paris has recently been carefully examined both by the French and the English electricians. The distance between the two places is 275 miles, viz., 74 miles between London and Dover, 21 miles from Dover to Calais, and 180 miles from Calais to Paris. It is very easy to speak over such a distance if the wires be aerial and of thick copper, but the insertion of underground wires at each end and of a cable in the middle places difficulties in the way that have to be surmounted. It is not a question of apparatus, it is solely the distribution of the electrical resistance and capacity

of the different portions of the line, and the arrangement and material of the wires.

Speech is already commercially maintained between Paris and Brussels (190 miles); Paris and Lille (158 miles); Paris and Rouen (80 miles); Paris and Havre (135 miles); Paris, Lyons, and Marseilles, the latter being a distance of nearly 600 miles, but in all cases over aerial wires, excepting for a short length (about 2 miles) of underground work in Paris.

The author has experimented on the cables between Dover and Calais, between Holyhead and Dublin, and between South Wales and Wexford. The conditions to be fulfilled are very simple. The circuit must be metallic, the material must be copper, and the product of the resistance of the line (R) and its capacity (K) must not exceed a certain figure. It has been determined roughly by experiment that when

KR	=	15,000	speech	becomes	impracticable,
	=	12,500	,,	,,	possible,
	=	10,000	,,	,,	good,
	=	7,500	,,	,,	very good,
	=	5,000	,,	,,	excellent,
	=	2,500	or under	,,	perfect.

We have thus a species of Beaufoy's scale applied to telephonic communication.

A circuit approaching as nearly as possible one between London and Paris was made on an artificial cable, and it was found to comply with the requirements.

An actual circuit was then made from Worcester, through 27 miles of the London underground system, to Baldock, on the Great Northern Railway, giving similar electrical conditions, and with the same result. It may be considered as absolutely settled that speech is possible between London and Paris.

In the United States speech is maintained between New York and Boston, 350 miles, and in many instances to distances exceeding that between London and Paris, but they have not been compelled to surmount the difficulties of underground wires at each end, and of a cable in the middle.

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7. *On the Purification of Sewage and Water contaminated with Organic Matter by Electrolysis.*[1] *By* W. Webster.

The paper was divided into four sections, bearing on the different values of the methods for the oxidation of organic matter in solution, leading up to the action produced by the electric current.

1. By natural processes due to the action of atmospheric oxygen dissolved in water.
2. By the action of the soil, due to oxygen in its pores, and also to the iron oxides therein acting as purveyors of oxygen.
3. By artificial disinfectants, represented by chemicals such as chromic acid, permanganates, chlorine, &c., chlorine having a powerful oxidising action upon all organic matter, living or dead.
4. The electric current produced by mechanical or chemical power. The fact that water and the salts contained therein are easily decomposed, provided the current of electricity is of sufficient intensity, is an explanation of the whole system. The changes taking place in sewage when electrolysed depend chiefly on the splitting up into their constituent parts of sodium, magnesium, and other chlorides, nascent oxygen and chlorine being set free at the positive, and the bases at the negative pole.

(*a*) The adaptation of the electric current to filters and filter beds in such a manner that putrefaction cannot take place in the pores of the filtering media owing to the constant presence of nascent oxidising agents, the filter always remaining clean, because the impurities are consumed

[1] Printed *in extenso* in the *Electrician*, October 4, 1889.

as fast as they present themselves, all harmful organisms being destroyed.

(*b*) The production of disinfectants for household purposes.

(*c*) The application of the electric current to plates of oxidisable and non-oxidisable material, fixed in such manner that sewage passing between them not only receives a precipitating agent, but the putrifying organic matter in solution is oxidised to any extent that may be required, the action being produced by metallic oxychlorides, nascent oxygen and chlorine, thus combining in one process the results obtained by both precipitation and irrigation, the intensity of the current not of necessity exceeding two volts, the action entirely depending on the quantity of the current employed. The oxidisable plates are by preference (for various reasons) of iron. It is contended that the process follows more nearly natural action than any other hitherto suggested.

TUESDAY, SEPTEMBER 17.

SUB-SECTION I.

The following Papers were read:—

1. *Blast Furnace Practice.*[1] *By* Sir LOWTHIAN BELL, *Bart.*, *F.R.S.*

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2. *Chemin de fer glissant.*[2] *By* Sir DOUGLAS GALTON, *K.C.B.*, *F.R.S.*

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3. *The Strength of Alloys at different Temperatures.* *By* Professor W. C. UNWIN, *F.R.S.*

The strength of the commonly used alloys, such as gun-metal and brass, at moderately high temperatures, is a question of some practical importance. It is well known that iron and copper decrease in tenacity as the temperature is raised, the latter in a very marked degree. There are also experiments showing a still more considerable decrease of tenacity in gun-metal. The author's attention was directed to the matter in studying some experiments made for the Admiralty in 1877. In these experiments copper, Muntz metal, and phosphor-bronze showed a tolerably regular decrease of tenacity as the temperature was raised to 500° F. But in the case of gun-metal the results were more anomalous. The gun-metals tried were all alloys of copper, tin, and zinc. In the bars tried the tenacity diminished tolerably regularly up to a temperature of 300° or 350°. But beyond that temperature there was a sudden decrease of tenacity generally of more than 50 per cent., and at a temperature of 500° in several cases the tenacity had become *nil.* Now at the high pressures, and correspondingly high temperatures, at which steam-engines are often worked, gun-metal is exposed in many cases to temperatures of 350° or 400°. It is practically important to know if at such temperatures its strength is seriously impaired. At any rate, the author found that there were but few experiments on the strength of alloys at different temperatures, and of some of these the trustworthiness was doubtful. Hence it appeared that it might be useful to make some new experiments.

In the present experiments the bars to be tested were fixed in an oil-bath heated by a gas-jet. The middle part of the bar for a length of two inches was turned down to a diameter of $\frac{1}{4}$ inch or $\frac{5}{16}$ inch. The temperatures were taken by

[1] This paper was mainly a repetition of the author's address as President of Section B. See also *Engineering*, vol. xlviii. p. 359.

[2] Published in the *Newcastle Daily Chronicle*, September 18, 1889.

a mercurial thermometer. It is believed that the temperatures are quite accurate except those above 600° F. Above 600° the thermometer behaved irregularly. The bars were broken in a small special testing-machine of the manometer type, the pressure on the diaphragm being balanced by a mercury column.

Rolled bars of yellow brass, Muntz metal, and Delta metal were tried, and the results on these are quite regular. Some bars of cast brass also gave very fairly regular results. The bars of gun-metal gave results of less regularity. This is due, in part at all events, to the fact that some of the bars cast first proved unsound, and new bars had to be cast to replace them. At some future time the author hopes to try a series of gun-metal bars all cast at the same time.

The results were plotted in a diagram, and show that in all cases the decrease of strength follows a regular law without any such sudden loss of strength as was shown in the Admiralty experiments. Even at temperatures of 600° to 650° all the bars had still a not inconsiderable tenacity.

The ultimate elongation of the bars in the two-inch test length was measured, and is given in the table. There is a peculiarity in the influence of temperature on the ductility of the bars. In most cases the ultimate elongation diminishes with increase of temperature. With Muntz metal the decrease is regular, and there is still considerable elongation before fracture at a temperature of 650°. With yellow brass (rolled) the decrease is more rapid, and there is very little elongation before fracture at temperatures above 500°. Cast brass behaves in the same way. The elongations of the gun-metal bars were very irregular, and at temperatures of 600° and upwards the elongation was extremely small.

On the other hand, in the case of the Delta metal bars the elongation increased regularly with increase of temperature.

The contraction of area was also measured. This follows generally the same law as the elongation at fracture, but the contractions of area are more irregular than the elongations.

Testing of Metals at different Temperatures.

Laboratory No.	Diameter in Ins.	Section in Sq. Ins.	Temperature. Fahr.	Tenacity in Tons per Sq. In.	Elongation in 2 ins. per Cent.	Contraction of Section per Cent.
			Yellow Brass (Rolled).			
938	·308	·07451	atmospheric	24·09	41·0	61·0
941	·309	·07499	258°	22·44	30·5	28·0
939	·307	·07402	400°	21·23	19·0	10·0
940	·312	·07645	500°	18·33	5·0	very little
942	·308	·07402	602°	15·86	2·5	,, ,,
943	·309	·07499	640°	14·49	1·0	,, ,
			Delta Metal (Rolled).			
945	·249	·04870	atmospheric	31·16	20·0	55·0
949	·243	·04638	260°	28·30	22·0	47·0
946	·249	·04870	400°	26·58	25·0	53·0
944	·249	·04870	500°	23·83	27·9	59·0
947	·245	·04714	570°	19·32	38·5	60·0
948	·240	·04524	650° abt.	16·04	33·0	48·0
			Muntz Metal (Rolled).			
950	·302	·07163	atmospheric	24·68	35·0	59·6
951	·309	·07499	300°	22·83	28·5	41·2
952	·310	·07548	400°	20·84	37·5	55·1
953	·311	·07596	500°	18·81	28·5	38·4
954	·306	·07354	600°	16·69	17·0	19·2
955	·310	·07548	650°	17·15	16·0	very little

Testing of Metals at different Temperatures—continued.

Laboratory No.	Diameter in Ins.	Section in Sq. Ins.	Temperature Fahr.	Tenacity in Tons per Sq. In.	Elongation in 2 ins. per Cent.	Contraction of Section per Cent.
			Gun-metal (Cast).			
977	·376	·11104	210°	11·66	10·0	15·8
980	·376	·11104	380°	12·26	17·0	18·2
979	·376	·11104	406°	11·06	12·5	12·8
957	·309	·07499	440°	12·30	16·5	7·6
981	·376	·11104	500°	7·84	13·0	14·8
978	·376	·11104	600°	5·22	1·5	2·1
982	·376	·11104	600°	7·84	—	very little
960	·311	·07596	615°	4·82	—	,, ,,
			Cast Brass.			
989	·376	·11104	atmospheric	12·45	24·0	16·4
991	·376	·11104	350°	11·83	27·5	23·4
992	·376	·11104	450°	10·40	23·0	22·5
990	·375	·11045	500°	7·69	11·5	16·2
993	·376	·11104	550°	7·68	13·5	17·8
994	·376	·11104	645°	3·23	—	very little
			Phosphor Bronze (Cast).			
995	·312	·07645	atmospheric	16·06	13·5	10·0
1000	·312	·07645	270°	14·16	12·5	12·4
997	·312	·07645	350°	12·26	7·5	10·0
999	·312	·07645	430°	12·41	10·5	8·7
996	·312	·07645	500°	11·10	6·0	6·3
998	·312	·07645	600°	8·17	3·5	2·5
			Copper (Rolled).			
1030	·313	·07694	atmospheric	17·84	10·0	49·2
1036	·313	·07694	210°	17·41	9·0	49·7
1031	·314	·07744	300°	16·43	8·0	49·5
1032	·313	·07694	410°	15·95	9·0	50·6
1033	·313	·07694	500°	15·09	7·0	37·7
1034	·314	·07744	600°	14·30	4·0	22·2
1035	·3125	·07670	600°	14·18	5·0	17·4
1037	·313	·07694	640°	13·70	4·5	17·1

4. *Records of River Volumes and Flood Levels.*

By C. E. De Rance, *Assoc.Inst.C.E., F.G.S., F.R.G.S.*

The basis of any legislation for the amelioration of floods should be an accurate knowledge of the levels reached by the dry-weather flow, the average flow, and the flood condition of our streams, extending over a long period; at present such information is rarely obtainable, and, except in waterworks drainage areas, but few observations exist as to the actual volume of water run off daily by the rivers of this country.

There can be little doubt that a permanent record of the height of floods, and the volume of the daily flow of our streams, is a matter of national necessity, and that such records could easily be obtained by the County Councils throughout the kingdom.

Were gauges painted on the county bridges by the county surveyors, a record could be made at least once a day by the county police on their ordinary rounds.

If the feet on the gauges were painted with the actual height above the Ordnance datum, it would facilitate comparison.

At important points on large streams automatic recording appliances might be placed under the direct charge of the county surveyor, who at such points might daily ascertain the number of cubic feet of water carried down. Where a river basin extends through two or more counties, the provision for joint action of a 'Watershed Board' seems to be already provided for, or suggested, by the Local Government Act of last year.

The author hoped the Committee of the Section would think the matter of sufficient importance to bring it before the Council, and that they would be inclined to concert such measures as would bring his suggestions, or a modification of them, before the Local Government Board, with the view of their giving the necessary sanction for such observations being carried out by the county officials.

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5. *Central Station Heating and Power Supply. Boston, U.S. (Prall's System). By* Wilson W. Phipson, *M.Inst.C.E.*

The author commences his paper by commenting upon the growing necessity of a central heating and power supply for cities and large towns, and of the dangers and inconveniences of the present system. He takes for his model the scheme in successful operation since 1887 in Boston, U.S., which is known as the Prall System, and exemplified by the Boston Heating Company.

This system consists in the constant circulation of water at a high temperature and pressure (viz., at 400° Fahr., and 250 lbs. on the square inch) from the batteries of boilers at the central station through the supply mains, and back to the boilers by means of the return mains, the circulation being maintained by means of pumps.

The ample scope of the system is next entered upon, showing that it is quite adequate to meet all requirements as regards both heat and power.

The method of determining the amount of heat or power supplied to the consumer is described.

With regard to the loss of heat by radiation, it has been reduced to a minimum by covering the mains with a non-conducting material, reducing the internal temperature of 400° of the pipe to 110° on the outside of the covering.

The area of the plant of the Boston Heating Company is shown by an accompanying map.

The construction of the pipe trenches, or conduits, is described, together with the sizes of mains, &c.

The details of the construction of the mains are fully given, showing that expansion-joints are used, which are fixed at every 100 feet to 150 feet, as well as one where the main changes direction, and of the special connection used in coupling the pipes together. Service-boxes to supply three houses are fixed under the footpaths, which are connected to the mains by a pipe 1″ in diameter. From these boxes the house supply is taken by means of copper pipes $\frac{1}{4}$″ to 1″ in diameter. At the end of the copper pipe, and inside the house, is fixed a vessel called a 'converter,' whose use is to permit the water to resolve itself into steam, the pressure of which is controlled by means of a reducing valve fixed on the copper pipe before it enters the converter. From this converter the house services are taken. If a supply of both heat and power is required, double or compound converters are used with two reducing valves, the power being taken from one and the heat from the other.

The pumping and boiler capacity of the central station are given, together with the latest additions to ensure economy of labour.

The paper concludes with the hope expressed by the author to see a successful central supply of heat and power system adopted in this country, and his thanks to Mr. A. V. Abbot, chief engineer to the Boston Heating Company, for his kind assistance in giving all possible data on the subject.

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6. *Note on the Godillot Furnace.* *By* A. GODILLOT.[1]

The author has devoted himself to the study of the combustion of poor materials and waste products, in order to utilise them in the heating of generators, and to secure an economical production of steam.

These waste products comprise, on the one hand, damp ligneous matter, such as spent tan, sugar cane refuse, &c.; and, on the other hand, chips and sawdust from workshops, the waste from looms, &c.

For burning these residues the author invented the 'grille-pavillon,' which answers perfectly. This grate is in the form of a half cone, it is formed of tapered bars, which bars, overlapping like the laths of a Venetian blind, intercept the finest particles of matter. This form of grate is especially suitable for mechanical stoking, it is only necessary to bring the combustible matter to a point at the top of the conical grate, and it will distribute itself naturally over the whole surface of the fire-bars.

Encouraged by the success of his first experiments, the author endeavoured to ascertain if the grates could not be modified so as burn good fuel in the form of slack, and small pieces, whether of coal, coke, or anthracite. To this new grate he has given the name 'grille à bassins étagés,' because it consists of a series of troughs arranged one below the other like steps.

Coal having a higher calorific power than the ligneous and other waste products, the difficulty was to avoid the rapid deterioration of the bars, and the formation of adhesive slag on the grate. In order to remedy these inconveniences water is caused to circulate through the bars.

The 'grille à bassins étagés' has, moreover, the same general form as the 'grille-pavillon'; it differs from it in the fact that to each bar is attached a tongue or rib, which dips into a cast-iron cistern filled with water. This water is led into the first cistern, and falls in a series of cascades, being finally received in the ash-pan.

The coal ignites on the first bars, descends gradually to the others, and finally accumulates on the horizontal grating where the slag forms, and whence the ashes are withdrawn.

This form of grate offers the following advantages:—(1) The feeding of the fuel is regular and automatic; (2) The combustion is practically complete, consuming the smoke; (3) With slack a higher degree of evaporation is secured than from the use of unscreened coal. Hence there is a first economy in the price of the fuel, and a second in the higher efficiency.

In a trial carried out by the Association of Steam Users of Paris it was proved that with slack a vaporisation of 8·58 kilogrammes of water was obtained per kilogramme of coal, with the boiler which, when furnished with an ordinary furnace, vaporised under similar circumstances only 6·5 kilogrammes of water per kilogramme of unscreened coal. (This unscreened coal was from the same pit as the slack burnt in the Godillot furnace.)

At the Paris Universal Exhibition the author heated by his process three sets of boilers, furnishing steam for motive power and for the generation of electricity. These were (1) a gramme installation with Davey Paxman and Co.'s boilers; (2) Roser installation; (3) Steinlen exhibit (formerly Ducommun's workshops). The first of these only is here described.

An idea of its general features was given by a diagram. Messrs. Davey Paxman have entrusted the author with the heating of their boilers, representing a total of 1,000 horse power (French). Five boilers (locomotive type) supply the engines which drive the dynamos belonging to the illuminated fountains, two arc-lamps in the galerie des machines, and in the central dome; the other four supply motive power to the British and American sections. The boiler-house is underground; an Archimedean screw elevator lifts the slack and supplies it to the grates by a series of helical distributors, which are driven by a small separate engine.

The boilers generate 12,000 kilo. of steam per hour. They have an immense amount of work to do in the evening when the illuminated fountains are playing.

[1] See *Engineering*, vol. xlviii., p. 336.

The firemen have simply to watch the fire and clear the grate-bars when necessary, the stoking being automatic, and the combustion is so complete that no smoke is observed.

In conclusion, the following advantages have been secured: (1) An increased efficiency; (2) The poorest fuel can be employed equally with the richer kinds, even in the state of dust; (3) Automatic stoking; (4) A complete consumption of smoke.

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7. *The Hopcraft Smokeless Furnace.*[1] *By* Lieut.-Colonel W. J. Engledue, *R.E.*

Sub-Section II.

1. *A Curve Ranger.* *By* Alex. P. Trotter.

Railway curves are generally set out in the field by the method of tangential angles. For this purpose a theodolite is used, with a book of tables of the angles for curves of different radii. The assistance of two chainmen with a chain is required. For each point on the curve the table must be consulted to find the tangential angle, and the vernier of the theodolite has to be set by the tangent screw, and signals have to be made to the chainmen.

The instrument brought before the Section is an application of the 21st proposition of the third book of Euclid, viz., 'The angles in the same segment of a circle are equal to one another.'

A half-silvered mirror, such as is used in sextants, is mounted on an axis at one end of a bar, the other being provided with a sight. The motion of the mirror on its axis allows its inclination to the sight to be adjusted.

To set out a curve, a pole or other mark is set up at each extremity, and the mirror is suitably adjusted. When the poles are seen, the one direct through the unsilvered part and the other by reflection in the silvered part of the mirror, in apparent coincidence and in the middle of the field, as shown by the vertical line engraved on the mirror, the instrument is then at a point on the curve required.

The mirror being clamped in position, the observer walks in the direction of the curve, and at suitable intervals places himself so that the poles at the extremities of the curve are seen in apparent coincidence. Where accuracy is required in small curves, a plumb-bob suspended from the axis of the mirror may be used to indicate the exact spot on the ground.

Only one adjustment is required for any one curve. No tables, assistants, chain, or knowledge of trigonometry are required. No cumulative error can occur in the use of this instrument, as is almost always the case with the method of tangential angles.

It frequently happens that a curve is required merely to be set out between two points and pass through a third point. In this case no calculation whatever is required for setting the mirror. The poles being set up at the extremities, the observer, standing over the third point, adjusts the mirror so that one of the poles is seen direct, and the other by reflection. The angle between the incident and the reflected ray at the mirror is the angle in the segment.

When the radius and the length of the chord are known, the mirror may be adjusted by the use of a scale divided into equal parts, representing the ratio of the chord to the radius. The arc may be greater or less than a semicircle.

When the mirror is inclined at an angle of 45° to the axis of the sight, the reflected ray makes a right angle with the direct ray, and the angle in a semicircle being a right angle, poles placed at the ends of a diameter will appear in coinci-

[1] See *Engineering*, vol. xlviii., p. 482.

dence when observed from any point on a semicircle: the ratio of the chord to the radius being of course 2.

It is easily seen from the geometrical construction that the length of the chord is twice the sine of twice the angle of inclination of the mirror to the axis of the sight. The ratio of the chord to the radius varies from 0 to 2.

A scale divided into twenty equal parts, with subdivisions, is engraved on the bar. The graduations are numbered by decimals up to the digit 2. To the mirror is attached a metal plate of an ovoid shape with a bevelled edge. This edge is the fiducial line by which the scale is read. When the plate is in a median or symmetrical position, the edge cuts the centre line of the scale at the extreme graduation marked 2.

The figure of the curved edge of the plate is a polar curve, whose equation is

$$r = a + b \sin 2\,\theta,$$

where a is the distance from the zero graduation to the axis of the mirror, and b is the length of the scale from zero to 2, and θ the inclination of the mirror.

A model of a family of curves of the equation

$$r = a \pm b \sin 2\,\theta$$

was exhibited to the meeting.

The ratio of the chord to the radius being known, the plate is set so that its bevelled edge cuts the scale at the graduation corresponding to the ratio. The mirror is then in adjustment. One side of the plate is for arcs less than a semicircle, the other for arcs greater than a semicircle.

The same method was suggested by Mr. R. C. May, and was described in the first volume of the 'Proceedings of the Institution of Civil Engineers,' in the year 1841. The instrument was a modified box sextant, and a specially prepared set of tables was required for setting the mirror. An arrow weighted with lead was released by a trigger to mark the exact spot on the ground.

A telescope may be used, but the instrument is not intended to compete with a theodolite for exact work. It is intended for simple and expeditious work by a single observer without assistants, and for those cases where a light, portable instrument, needing no tables or calculations, will be appreciated.

An ordinary five-inch theodolite weighs 12 lbs. without its case. This instrument weighs 1 lb. 10 oz., or with telescope, 2 lbs.

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2. *On the Comparative Cost of working English and American Railways.*[1] *By* E. B. Dorsey, *M.Am.Soc.C.E.*

The author exhibited tables comparing the working expenses in 1888 on the London and North Western, Great Northern, Midland, Great Western, and Great Eastern railways of England with those on the Pennsylvania railroad and the Knoxville Branch of the Louisville and Nashville system, these two last-named roads representing the extreme types of American railway construction—the first being one of the best, and the last one of the most cheaply constructed roads in America.

It was shown that on the English railways, which have cost from four to six times more to construct than the American roads, the cost for transporting freight is more than double the American cost, whereas it should be less, or why make the increased outlay for superior construction?

The author thinks that the great difference in favour of American railways in the working expenses is owing principally to the following reasons:—

1st. The trains on the American railways carry much larger loads than those on the English roads.

2nd. The universal use on the American railways of rolling-stock with bogie-trucks, which run with much less friction and wear and tear than the English rolling-stock with its long rigid wheel base.

[1] Printed *in extenso* in the *Engineer*, vol. lxviii., p. 275.

3rd. The general use on the American railways of freight cars or waggons, carrying a greater percentage of paying load to dead weight than those used on the English railways.

4th. The lower speed at which the American goods trains run.

5th. The use on the American railways of heavier locomotives, which haul heavier loads than can be done by the lighter ones used on the English railways.

6th. The use of locomotives on the American railways with outside cylinders and connections, which can be more cheaply and easily repaired than those with inside cylinders, used on the English railways.

7th. The use on the American railways of collecting and distributing goods trains, which load and unload at the stations goods in less than car-load quantities, thus avoiding the use of waggons only partially loaded, as is the custom on the English railways; the Americans apply to their goods trains the same principle that the English railway managers now apply to their milk-trains.

The tables show the following percentages against the London and North-Western and Great Northern railways, when compared with the Pennsylvania Railroad division:—

1888	Percentage against	
	London and North-Western	Great Northern
Average freight train load in tons	171	263
Average charge for transporting 1 ton 1 mile	215	215
Average cost of transporting 1 ton 1 mile	152	172
Average cost of transporting 1 ton 1 mile, deducting on the English roads all 'Traffic Expenses,' 36 and 34 per cent. respectively, and deducting nothing on the American road.	62	80
Average cost of transporting 1 ton 1 mile, deducting all 'Traffic Expenses' on all roads.	149	176
Equated cost of train mile, provided the present train load on the English roads should be transported at the same cost per ton per mile as on the American road.	114	147

The present freight charge on pig iron from Stoke-on-Trent to Liverpool is 5*s.* 5*d.* per ton, distance 55 miles. From Birmingham, Alabama, to Pensacola (both in the United States) the freight charge is \$1.40 = 5*s.* 7½*d.* (1*l.* = \$4.80) distance 280 miles—the freight being about the same for five times the distance. This is a practical illustration of the difference between English and American railway practice, and its effect upon the trade of the country. The Birmingham district in the United States is only three or four years old, it will produce this year over 800,000 tons of pig iron. With railway freights as high as they are in England the iron could not be profitably made, and the whole district would be depopulated and abandoned. These are stern facts and cannot be put aside by saying that they are estimates or theoretical possibilities.

The preceding remarks and opinions are not founded on theory or some new invention, but are founded upon actual workings of many years of all the American and Canadian railways, embracing over 170,000 miles of operated lines with over 1,100,000 cars and carriages constructed and run on the principle advocated in this paper.

This can no longer be considered an experimental test. What is done in America on such a very large scale could surely be done here.

When the present railways were constructed England had comparatively no commercial rivals. Now, strong and in some cases successful, ones have sprung up on all sides. If anyone, then, had told the English farmer that wheat raised in the interior of North America, Australia, or India, would compete successfully in the English market with the wheat raised by the farmers of the United Kingdom,

the person making this prediction would have been thought crazy. But suppose he had gone farther and predicted that the fresh beef and mutton raised and consumed in England, would find a successful rival in that raised in the Rocky Mountains of America, or on the Pampas of South America, or in the interior of Australia, the English farmer would have thought this prediction too absurd to answer or notice. Both of these imaginary predictions have now been realised, and the farmer finds that, handicapped as he is by high charges for transportation to market, he cannot compete; consequently his market is lost and his lands have depreciated greatly in value. The remedy is simple:—

Let the railways give the English farmer the same rates to market that his foreign competitor pays, which can be done by adopting modern rolling stock and railway practice; or construct cheap railways on the American plan that will give cheap transportation. When this is done the English farming lands will greatly increase in value, manufacturers and miners will increase their work and be placed on a favourable footing to compete with other countries in the markets of the world.

After six years careful study of the English railways, the author thinks that it is possible, by adopting the practice that has answered very well in other places, to make very large reductions in the cost of railway transportation, and that without diminishing the present dividends.

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3. *The Draught of Horses.*[1] *By* T. H. Briggs.

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4. *The Application of the Transporting Power of Water to the deepening and improvement of Rivers.*[2] *By* W. H. Wheeler, *M.Inst.C.E.*

The object of this paper is to show :—

(1) That the transporting power of water may be economically applied to the deepening and improvement of rivers.

(2) That under favourable conditions this can be accomplished by breaking up shoals, or the natural bed of a river, by mechanical agency, and by mixing the material with the water and allowing it to be carried away to the sea or estuary in suspension.

The successful application of the process depends on the complete disintegration of the material and the thorough mixing of the particles so disintegrated with the water by continuous stirring or churning, and so reducing it to the condition in which alluvial matter is transported by rivers when in a turbid condition.

It is shown by the paper that all rivers carry during seasons of flood large quantities of matter in suspension, and it is contended that what is thus done naturally may be imitated artificially, and the rivers made the agents for their own improvement.

The disintegrating and mixing process which is effected by frosts and rains on the alluvial matter which is carried away to sea may be applied to the bed of a river, or shoals, by mechanical agency, and the material thus broken up be transported away by the current The erosive and transporting power of water is dealt with, and examples quoted of the enormous amount of alluvial matter transported by some of the larger rivers. Instances are quoted to show that the quantity transported amounts to as much in some cases as 2 lbs. of solid matter in every cubic foot of water, or $\frac{1}{32}$nd of the whole weight.

Examples are given to show that a current of 3 feet per second is sufficient to carry away material broken up from the bed of a river and mixed with the water in the form of mud at the rate of 11·8 tons in twenty-four hours for every square foot of area of water contained in a given section of the stream; the transporting power being equal to $\frac{1}{600}$th of the whole mass of water in motion.

The power of water to transport material of much greater specific gravity than

[1] Published privately by the author (Bradford, Yorks).

[2] Printed *in extenso* in the *Engineer*, October 25 and November 8, 1889.

itself is shown to be due to the ever-varying motion of the particles of water as they move along the channel, the numerous whirlpools and eddies caused by irregularities in the contour of the channel giving a rotary and upward motion which prevents the particles of matter in suspension from being deposited. The power of water to transport solid material depends on the velocity which governs the transporting power in two ways: one certain, when, the quantity of water being constant, the amount of material carried will vary directly as the velocity, and as affected by the time that gravity has to act on the particles while travelling a given distance; the other uncertain, and being due to the increase of eddies and whirling motions set up by the increased momentum of the stream. Also depending on the fineness of the particles and the specific gravity of the material in suspension.

A table is given showing the results of experiments on the weight of different kinds of clay, sand, and warp; the time taken to deposit in water; and the quantity transported by a stream of water running at the rate of one foot per second.

The second part of the paper deals with the practical application of the process, and several instances are quoted of its successful adoption. The processes described are harrowing; scouring caused by the use of artificial dams attached to barges; forcing water and air into shoals and sand-beds by pumps worked by steam power; also pumping up the material and delivering on to the surface of the ebbing current; and breaking up beds of clay by means of revolving rollers drawn along the bed of the stream.

The process has been successfully applied to the deepening of rivers in the Fen District, at a cost very considerably under that by which the improvement could have been effected by the ordinary method of dredging; and at Tilbury Dock the cleansing of the tidal basin is now carried out at one-fortieth of the cost that used to be incurred in removing the deposit by dredging.

As the successful application of the process depends on the thorough disintegration of the particles to be moved by continual stirring or churning, the author has, after numerous trials, designed an improvement on existing machines, which, while breaking up and disintegrating shoals composed of clay, sand, or warp, at the same time thoroughly mixes the material with the water, allowing it to be effectively transported by the ebb current clear of the channel to be improved.

SECTION H.—ANTHROPOLOGY.

PRESIDENT OF THE SECTION—Professor Sir WILLIAM TURNER, M.B., LL.D., F.R.SS. L. & E.

THURSDAY, SEPTEMBER 12.

The following Papers were read:—

1. *On the Advisability of assigning Marks for Bodily Efficiency in the Examinations of Candidates for the Public Services. By* FRANCIS GALTON, *F.R.S.*—See Reports, p. 471.

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2. *On the Principle and Methods of assigning Marks in Examinations on Bodily Efficiency. By* FRANCIS GALTON, *F.R.S.*—See Reports, p. 474.

The PRESIDENT delivered the following Address:—

On Heredity.

TWENTY-SIX years have passed by since the British Association for the Advancement of Science last assembled in this city. Many of the incidents of that meeting are still fresh in my memory, the more vividly, perhaps, because it was the first meeting of the Association that I had attended. The weather, so important a factor in most of our functions, was dry and bright. The visitor, instead of being enshrouded in that canopy of mist and smoke which so often meets the traveller as he approaches your city, was greeted with light and sunshine. The cordial welcome and reception so freely granted by the community, and more especially the princely yet gracious hospitality exercised by the President, your eminent townsman, now Lord Armstrong, are all deeply imprinted on my memory. But, apart from these attractions, which added so much to the amenities of the occasion, the meeting was one of deep interest to all those Members and Associates who were engaged in biological study.

Lyell's famous book on the 'Antiquity of Man' had been published shortly before. The essays on the 'Origin of Species' by natural selection, by Charles Darwin and Alfred Russel Wallace, had appeared only five years earlier in the Journal of the Linnæan Society, and in 1859 Darwin's treatise on the 'Origin of Species,' in which its illustrious author summarised the facts he had collected and the conclusions at which he had arrived, had been published. Although no President of the British Association had up to that time given his adhesion to the new theory, yet it was clear that men were beginning to see, in many instances perhaps only dimly, how the theory of evolution by natural selection was destined to work a remarkable change, amounting almost to a revolution, in our conceptions of biological questions generally, and their applicability to the study of man.

At that time Anthropology had not assumed so definite a position in the work of the Association as it now possesses. Neither a department, nor a section, was devoted to it, and the subjects which it embraces were scattered abroad, either in

the department of Anatomy and Physiology, in the section of Geography and Ethnology, in that of Geology, or in that of Statistics. It is true that a vigorous attempt was made about that time to give it a more independent position, but it was not until the Association met in Nottingham, in 1866, that it was assigned a definite department, and at the Montreal meeting, in 1884, Anthropology assumed the dignity of a section.

But although the youngest section of the Association, the Science of Man is not the youngest of the sciences. Long before the British Association came into existence, man, in his physical, racial, geological, and psychological aspects, had been studied by hosts of able and industrious inquirers. All that the Association had done in establishing a special section of Anthropological Science has been to bring together, as it were, into a single focus all those workers who apply themselves to the study of man in his various aspects.

As presiding over the proceedings of the Section on this occasion, it is a part of my duty to open its public business with an address. For me, as doubtless for many of those who have preceded me in this honourable office, my mind has been somewhat exercised in the choice of a subject. In a branch of biological science so vast as Anthropology, in which the room for selection is so ample, the difficulty of making a choice is perhaps still further increased. As a professional anatomist, whose life's work it has been to study the structure of the human body in its normal aspects, to inquire into the variations which it exhibits in different individuals, and to compare its structure with that of various forms of animal life, it at first occurred to me that an address on the physical characteristics of some of the races of men would be appropriate. But further consideration led me to think that such a subject would be too technical for a general audience, and that it might perhaps be productive of greater interest on the part of my auditors if I selected a topic which, whilst strictly scientific in all its bearings, yet appeals more distinctly to the popular mind, and is now attracting attention. Hence I have chosen the subject of Heredity, by which I mean that special property through which the peculiarities of an organism are transmitted to its descendants throughout successive generations, so that the offspring, in their main features, resemble their parents.

The subject of Heredity, if I may say so, is in the air at the present time. The journals and magazines, both scientific and literary, are continually discussing it, and valuable treatises on the subject are appearing at frequent intervals. But though so important a topic of existing scientific thought and speculation, it is by no means a new subject, and certain of its aspects were under discussion so far back as the time of Aristotle. The prominence which it has assumed of late years is in connection with its bearing on the Darwinian Theory of Natural Selection, and, consequently, biologists generally have had their attention directed to it. But in its relations to Man, his structure, functions, and diseases, it has long occupied a prominent position in the minds of anatomists, physiologists, and physicians. That certain diseases, for example, are hereditary was recognised by Hippocrates, who stated generally that hereditary diseases are difficult to remove, and the influence which the hereditary transmission of disease exercises upon the duration of life is the subject of a chapter in numerous works on practical medicine, and forms an important element in the valuation of lives for life insurance.

The first aspect of the question which has to be determined is whether any physical basis can be found for Heredity. Is there any evidence that the two parents contribute each a portion of its substance to the production of the offspring so that a physical continuity is established between successive generations? The careful study, especially during the last few years, of the development of a number of species of animals mostly but not exclusively amongst the Invertebrata, by various observers, of whom I may especially name Bütschli, Fol, E. Van Beneden, and Hertwig, has established the important fact that the young animal arises by the fusion within the egg or germ-cell of an extremely minute particle derived from the male parent with an almost equally minute particle derived from the germ-cell produced by the female parent. These particles are technically termed in the

former case the *male pronucleus*, in the latter the *female pronucleus*, and the body formed by their fusion is called the *segmentation nucleus*. These nuclei are so small that it seems almost a contradiction in terms to speak of their magnitude; rather one might say their minimitude, for it requires the higher powers of the best microscopes to see them and follow out the process of conjugation. But notwithstanding their extreme minuteness, the pronuclei and the segmentation nucleus are complex both in chemical and molecular structure. From the segmentation nucleus produced by the fusion of the pronuclei with each other, and from corresponding changes which occur in the protoplasm of the egg which surrounds it, other cells arise by a process of division, and these in their turn also multiply by division. These cells arrange themselves in course of time into layers which are termed the germinal or embryonic layers. From these layers arise all the tissues and organs of the body, both in its embryonic and adult stages of life. The starting-point of each individual organism—*i.e.*, of each new generation—is therefore the segmentation nucleus. Every cell in the adult body is derived by descent from that nucleus through repeated division. As the segmentation nucleus is formed by the fusion of material derived from both parents, a physical continuity is established between parents and offspring. But this physical continuity carries with it certain properties which cause the offspring to reproduce, not only the bodily configuration of the parent, but other characters. In the case of Man we find along with the family likeness in form and features a correspondence in temperament and disposition, in the habits and mode of life, and sometimes in the tendency to particular diseases. This transmission of characters from parent to offspring is summarised in the well-known expression that 'like begets like,' and it rests upon a physical basis.

The size of the particles which are derived from the parents, called the male and female pronuclei, the potentiality of which is so utterly out of proportion to their bulk, is almost inconceivably small when compared with the magnitude of the adult body. Further, by the continual process of division of the cells, the substance of the segmentation nucleus is diffused throughout the body of the new individual produced through its influence, so that each cell contains but an infinitesimal particle of it. The parental dilution, if I may so say, is so attenuated as to surpass the imagination of even the most credulous believer in the attenuation of drugs by dilution. And yet these particles are sufficient to stamp the characters of the parents, of the grandparents, and of still more remote ancestors on the offspring and to preserve them throughout life, notwithstanding the constant changes to which the cells forming the tissues and organs of the body are subjected in connection with their use and nutrition. So marvellous, indeed, is the whole process, that even the exact contributions to recent knowledge on the fusion of the two pronuclei, instead of diminishing our wonder, have intensified the force of the expression '*magnum hereditatis mysterium*.'

In considering the question of how new individuals are produced, one must keep in mind that it is not every cell in the body which can act as a centre of reproduction for a new generation, but that certain cells, which we name germ-cells and sperm-cells, are set aside for that purpose. These cells, destined for the production of the next generation, form but a small proportion of the body of the animal in which they are situated. They are, as a rule, marked off from the rest of the cells of its body at an early period of development. The exact stage at which they become specially differentiated for reproductive purposes varies, however, in different organisms. In some organisms, as is said by Balbiani to be the case in *Chironomus*, they apparently become isolated before the formation of the germinal layers is completed; but, as a rule, their appearance is later, and in the higher organisms not until the development of the body is relatively much more advanced.

The germ-cells after their isolation take no part in the growth of the organism in which they arise, and their chief association with the other cells of its body is that certain of the latter are of service in their nutrition. The problem, therefore, for consideration is the mode in which these germ or reproductive cells become influenced, so that after being isolated from the cells which make up the

bulk of the body of the parent they can transmit to the offspring the characters of the parent organism. Various speculations and theories have been advanced by way of explanation. The well-known theory of Pangenesis, which Charles Darwin with characteristic moderation put forward as merely a provisional hypothesis, assumes that *gemmules* are thrown off from each different cell or unit throughout the body which retain the characters of the cells from which they spring; that the gemmules aggregate themselves either to form or to become included within the reproductive cells; and that in this manner they and the characters which they convey are capable of being transmitted in a dormant state to successive generations, and to reproduce in them the likeness of their parents, grandparents, and still older ancestors.

In 1872, and four years afterwards, in 1876, Mr. Francis Galton published most suggestive papers on Kinship and Heredity.[1] In the latter of these papers he developed the idea that 'the sum total of the germs, gemmules, or whatever they may be called,' which are to be found in the newly fertilised ovum, constitute a *stirp*, or root. That the germs which make up the stirp consist of two groups—the one which develops into the bodily structure of the individual, and which constitutes, therefore, the personal structure; the other, which remains latent in the individual, and forms, as it were, an undeveloped residuum. That it is from these latent or residual germs that the sexual elements intended for producing the next generation are derived, and that these germs exercise a predominance in matters of heredity. Further, that the cells which make up the personal structure of the body of the individual exercise only in a very faint degree any influence on the reproductive cells, so that any modifications acquired by the individual are barely, if at all, inherited by the offspring.

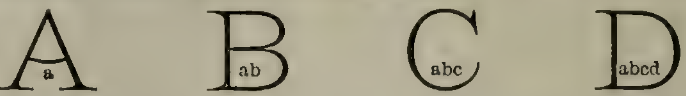
Subsequent to the publication of Mr. Galton's essays, valuable contributions to the subject of Heredity have been made by Professors Brooks, Jaeger, Naegeli, Nussbaum, Weismann, and others. Professor Weismann's theory of Heredity embodies the same fundamental idea as that propounded by Mr. Galton; but as he has employed in its elucidation a phraseology which is more in harmony with that generally used by biologists, it has had more immediate attention given to it. As Weismann's essays have, during the present year, been translated for and published by the Clarendon Press,[2] under the editorial superintendence of Messrs Poulton, Schönland, and Shipley, they are now readily accessible to all English readers.

Weismann asks the fundamental question, 'How is it that a single cell of the body can contain within itself all the hereditary tendencies of the whole organism?' He at once discards the theory of pangenesis, and states that in his belief the germ-cell, so far as its essential and characteristic substance is concerned, is not derived at all from the body of the individual in which it is produced, but directly from the parent germ-cell from which the individual has also arisen. He calls his theory the *continuity of the germ-plasm*, and he bases it upon the supposition that in each individual a portion of the specific germ-plasm derived from the germ-cell of the parent is not used up in the construction of the body of that individual, but is reserved unchanged for the formation of the germ-cells of the succeeding generation. Thus, like Mr. Galton, he recognises that in the stirp or germ there are two classes of cells destined for entirely distinct purposes: the one for the development of the *soma* or body of the individual, which class he calls the *somatic* cells; the other for the perpetuation of the species, *i.e.*, for reproduction.

In further exposition of his theory Weismann goes on to say, as the process of fertilisation is attended by a conjugation of the nuclei of the reproductive cells—the pronuclei referred to in an earlier part of this address—that the nuclear substance must be the sole bearer of hereditary tendencies. Each of the two uniting nuclei would contain the germ-plasm of one parent, and this germ-plasm also would contain that of the grandparents as well as that of all previous generations.

[1] *Proc. Roy. Soc. Lond.*, 1872, and *Journ. Anthrop. Inst.*, vol. v., 1876.
[2] Oxford, 1889.

To make these somewhat abstract propositions a little more clear, I have devised the following graphic mode of representation:—



Let the capital letters A, B, C, D, &c., express a series of successive generations. Suppose A to be the starting-point, and to represent the somatic or personal structure of an individual; then *a* may stand for the reproductive cells, or germ-plasm, from which the offspring of A, viz. B, is produced. B, like A, has both a personal structure and reproductive cells or germ-plasm, the latter of which is represented by the letters *ab*, which are intended to show that whilst belonging to B they have a line of continuity with A. C stands for an individual of the third generation, in which the reproductive plasm is indicated by *abc*, to express that, though within the body of C, the germ-plasm is continuous with that of both *b* and *a*. D also contains the reproductive cells *abcd*, which are continuous with the germ-plasm of the three preceding generations, and so on.

It follows, therefore, from this theory that the germ-plasm possesses throughout the same complex chemical and molecular structure, and that it would pass through the same stages when the conditions of development are the same, so that the same final product would arise. Each successive generation would have therefore an identical starting-point, so that an identical product would arise from all of them.

Weismann does not absolutely assert that an organism cannot exercise a modifying influence upon the germ-cells within it; yet he limits this influence to such slight effect as that which would arise from the nutrition and growth of the individual, and the reaction of the germ-cell upon changes of nutrition caused by alteration in growth at the periphery, leading to some change in the size, number, and arrangements of its molecular units. But he throws great doubt upon the existence of such a reaction, and he, more emphatically than Mr. Galton, argues against the idea that the cells which make up the somatic or personal structure of the individual exercise any influence on the reproductive cells. From his point of view the structural or other properties which characterise a family, a race, or a species are derived solely from the reproductive cells through continuity of their germ-plasm, and are not liable to modification by the action on them of the organs or tissues of the body of the individual organism in which they are situated. To return for one moment to my graphic illustration in elucidation of this part of the theory. The cells which make up the personal structure of A or B would exercise no effect upon the character of the reproductive cells *a* or *ab* contained within them. These latter would not be modified or changed in their properties by the action of the individual organism A or B. The individual B would be in hereditary descent, not from A + *a*, but only from *a*, with which its germ-plasma *ab* would be continuous, and through which the properties of the family, race, or species would be transmitted to C, and so on to other successive generations.

The central idea of Heredity is permanency; that like begets like, or, as Mr. Galton more fitly puts it, that 'like *tends* to produce like.' But though the offspring conform with their parents in all their main characteristics, yet, as everyone knows, the child is not absolutely like its parents, but possesses its own character, its own individuality. It is easy for anyone to recognise that differences exist amongst men when he compares one individual with another; but it is equally easy for those who make a special study of animals to recognise individual differences in them also. Thus a pigeon or canary fancier distinguishes without fail the various birds in his flock, and a shepherd knows every sheep under his charge. But the anatomist tells us that these differences are more than superficial—that they also pervade the internal structure of the body. In a paper which I read to the meeting of this Association in Birmingham so long ago as 1865,[1] after relating a series of instances of variation in structure observed in the dissections of a number of human

[1] *Transactions of Sections*, p. 111, 1865, and *Trans. Roy. Soc.* Edinburgh, vol. xxiv., 1865.

bodies, I summarised my conclusion as follows: 'Hence, in the development of each individual, a morphological specialisation occurs both in internal structure and external form by which distinctive characters are conferred, so that each man's structural individuality is an expression of the sum of the individual variations of all the constituent parts of his frame.'

As in that paper I was discussing the subject only in its morphological relations, I limited myself to that aspect of the question; but I might with equal propriety have also extended my conclusion to other aspects of man's nature.

Intimately associated, therefore, with the conception of Heredity—that is, the transmission of characters common to both parent and offspring—is that of Variability—that is, the appearance in an organism of certain characters which are unlike those possessed by its parents. Heredity, therefore, may be defined as the perpetuation of the like; Variability, as the production of the unlike.

And now we may ask, Is it possible to offer any feasible explanation of the mode in which variations in organic structure take their rise in the course of development of an individual organism? Anything that one may say on this head is of course a matter of speculation, but certain facts may be adduced as offering a basis for the construction of an hypothesis, and on this matter Professor Weismann makes a number of ingenious suggestions.

Prior to the conjugation of the male and female pronuclei to form the segmentation nucleus a portion of the germ-plasm is extruded from the egg to form what are called the *polar bodies.* Various theories have been advanced to account for the significance of this curious phenomenon. Weismann explains it on the hypothesis that a reduction of the number of ancestral germ-plasms in the nucleus of the egg is a necessary preparation for fertilisation and for the development of the young animal. He supposes that by the expulsion of the polar bodies one half the number of ancestral germ-plasms is removed, and that the original bulk is restored by the addition of the male pronucleus to that which remains. As precisely corresponding molecules of this plasm need not be expelled from each ovum, similar ancestral plasms are not retained in each case; so that diversities would arise even in the same generation and between the offspring of the same parents.

Minute though the segmentation nucleus is, yet microscopic research has shown that it is not a homogeneous structureless body, but is built up of different parts. Most noteworthy is the presence of extremely delicate threads or fibrils, called the *chromatin filaments,* which are either coiled on each other, or intersect to form a network-like arrangement. In the meshes of this network a viscous—and, so far as we yet know, structureless—substance is situated. Before the process of division begins in the segmentation nucleus these filaments swell up and then proceed to arrange themselves at first into one and then into two star-like figures before the actual division of the nucleus takes place.[1] It is obvious, therefore, that the molecules which enter into the formation of the segmentation nucleus can move within its substance, and can undergo a readjustment in size and form and position. But this readjustment of material is, without doubt, not limited to those relatively coarse particles which can be seen and examined under the microscope, but applies to the entire molecular structure of the segmentation nucleus. Now it must be remembered that the cells of the embryo from which all the tissues and organs of the adult body are derived are themselves descendants of the segmentation nucleus, and they will doubtless inherit from it both the power of transmitting definite characters and a certain capacity for readjustment both of their constituent materials and the relative positions which they may assume towards each other. One might conceive, therefore, that if in a succession of organisms derived from common ancestors the molecular particles were to be of the same composition and to arrange themselves in the segmentation nucleus and in the cells derived from it on the same lines, these successive generations would be alike; but if the lines of adjustment and the molecular constitution were to vary in the different generations, then the products

[1] The observations more especially of Flemming, E. Van Beneden, Strasburger, and Carnoy may be referred to in connection with the changes which take place in nuclei prior to and in connection with their division.

would not be quite the same. Variations in structure, and to some extent also in the construction of parts, would arise, and the unlike would be produced.

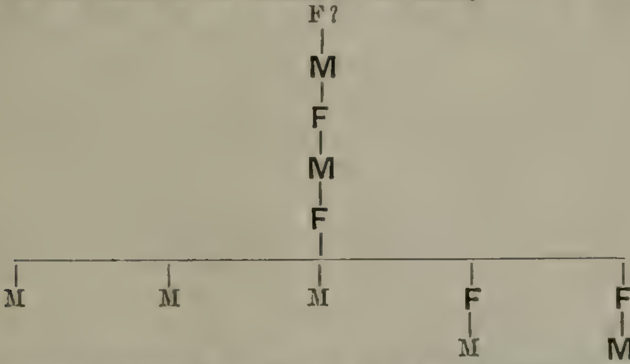
In this connection it is also to be kept in mind that in the higher organisms, and, indeed, in multicellular organisms generally, an individual is derived, not from one parent only, but from two parents. Weismann emphasises this combination as the cause of the production of variations and the transmission of hereditary individual characters. If the proportion of the particles derived from each parent and the forces which they exercise were precisely the same in any individual case, then one could conceive that the product would be a mean of the components provided by the two parents. But if one parent were to contribute a larger proportion than the other to the formation of a particular organism, then the balance would be disturbed, the offspring in its character would incline more to one parent than to the other, according to the proportion contributed by each, and a greater scope for the production of variations would be provided. These differences would be increased in number in the course of generations, owing to new combinations of individual characters arising in each generation.

As long as the variations which are produced in an organism are collectively within a certain limitation, they are merely individual variations, and express the range within which such an organism, though exhibiting differences from its neighbours, may yet be classed along with them in the same species. It is in this sense that I have discussed the term Variability up to the present stage of this address. Thus all those varieties of mankind which, on account of differences in the colour of the skin, we speak of as the white, black, yellow races and red-skins are men, and they all belong to that species which the zoologists term *Homo sapiens.*

But the subject of Variability cannot, in the present state of science, be confined in its discussion to the production of individual variations within the limitations of a common species. Since Charles Darwin enunciated the proposition that favourable variations would tend to be preserved, and unfavourable ones to be destroyed, and that the result of this double action, by the accumulation of minute existing differences, would be the formation of new species by a process of natural selection, this subject has attained a much wider scope, has acquired increased importance, and has formed the basis of many ingenious speculations and hypotheses. As variations, when once they have arisen, may be hereditarily transmitted, the Darwinian theory might be defined as Heredity modified and influenced by Variability.

This is not the place to enter on a general discussion of the Darwinian theory, and even if it were, the time at our disposal would not admit of it. But there are some aspects of the theory which would need to be referred to in connection with the subject now before us. It may be admitted that many variations which may arise in the development of an individual, and which are of service to that individual, would tend to be preserved and perpetuated in its offspring by hereditary transmission. But it is also without question that variations which are of no service, and, indeed, are detrimental to the individual in which they occur, are also capable of being hereditarily transmitted. This statement is amply borne out in the study of those important defects in bodily structure which pathologists group together under the name of Congenital Malformations. I do not require to go into much detail on this head, or to cite cases in which the congenital defect can only be exposed by dissection, but may refer, by way of illustration, to one or two examples in which the defect is visible on the surface of the body. The commonest form of malformation the hereditary transmission of which has been proved is where an increase in the number of digits on the hands or feet, or on both, occurs in certain families, numerous instances of which have now been put on record. But in other families there is an hereditary tendency to a diminution in the number of digits or to a defect in the development of those existing. I may give an illustration which occurred in the family of one of my pupils, the deformity in which consisted in a shortening or imperfect growth of the metacarpal bone of the ring finger of the left hand, so that the length of that finger was much below the normal. This family defect was traceable throughout six

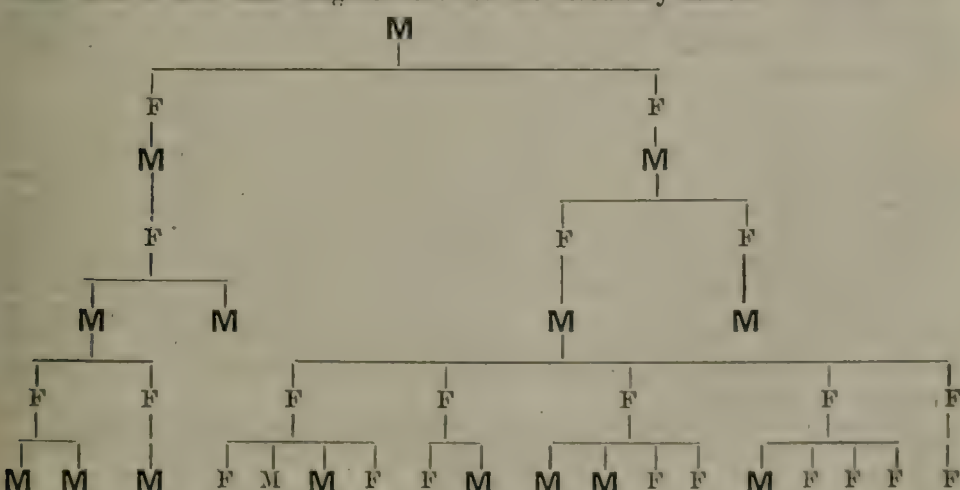
generations, and perhaps even in a seventh, and was, as a rule, transmitted alternately from the males to the females of the family[1]—



In this and the following diagrams M stands for male, F for female, whilst the black type (**M** or **F**) marks the individual or generation in which the variation occurred.

Another noticeable deformity which is known to be hereditary in some families, and which may be familiar to some of my auditors, is that of imperfect development of the upper lip and roof of the mouth, technically known as hare-lip and cleft palate.

These examples illustrate what may be called the coarser kinds of hereditary deformity, where the redundancies or defects in parts of the body are so gross as at once to attract attention. But modifications or variations in structure that can be transmitted from parent to offspring are by no means limited to changes which can be detected by the naked eye. They are sometimes so minute as to be determined rather by the modifications which they occasion in the function of the organ than by the ready recognition of structural variations. One of the most interesting of these is the affection known as Daltonism, or colour-blindness, which has distinctly been shown to be hereditary, and which is due, apparently in the majority of cases, to a defect in the development of the retina, or of the nerve of sight which ends in it, though in some instances they may be occasioned by defective development of the brain itself. Dr. Horner has related a most interesting family history,[2] in which the colour-blindness was traced through seven generations. In this family the males were the persons affected, though the peculiarity was transmitted through the females, who themselves remained unaffected. The family tree showed that in the sixth generation seven mothers had children. Their sons, collectively nine in number, were all colour-blind with the exception of one son, while none of their nine daughters showed the hereditary defect.



[1] *Journ. Anat. and Phys.*, vol. xviii., page 463.
[2] Cited in *Die Allgemeine Pathologie*, by Dr. Edwin Klebs, Jena, 1887.

The eye is not the only organ of sense which exhibits a tendency to the production of hereditary congenital defects. The ear is similarly affected, and intimately associated with congenital deafness is an inability to speak articulately, which occasions the condition termed Deaf-mutism. Statisticians have given some attention to this subject, both as regards its relative frequency and its hereditary character. The writer of the article 'Vital Statistics,' in the Report of the Irish Census Commissioners during the decades ending 1851, 1861, 1871, has discussed at some length the subject of congenital deaf-mutism, and has produced a mass of evidence which proves that it is often hereditarily transmitted. In the Census Report for 1871,[1] 3,297 persons were returned as belonging to this class, and in 393 cases the previous or collateral branches of the family were also mute. In 211 of these the condition was transmitted through the father; in 182 through the mother. In 2,579 cases there was one deaf-mute in a family; in 379 instances, two; in 191 families, three; in 53, four; in 21, five; in 5, six; and in each of two families no fewer than seven deaf-mutes were born of the same parents. In one of these two families neither hereditary predisposition nor any other probable physiological or pathological reason was assigned to account for the peculiarity, but in the other family the parents were first cousins. Mr. David Buxton, who has paid great attention to this subject,[2] states that the probability of congenital deafness in the offspring is nearly seven times greater when both parents are deaf than when only one is so; in the latter case the chance of a child being born deaf is less than three-quarters per cent.; in the former, the chances are that 5 per cent. of the children will be deaf-mutes. Mr. Buxton refers to several families where the deaf-mutism has been transmitted through three successive generations, though in some instances the affection passes over one generation to re-appear in the next. He also relates a case of a family of sixteen persons, eight of whom were born deaf and dumb, and one at least of the members of which transmitted the affection to his descendants as far as the third generation. There can be little doubt that congenital deaf-mutism, in the great majority of instances, is associated with a defective development, and therefore a structural variation of the organ of hearing, though in some cases, perhaps, the defect may be in the development of the brain itself.

Although a sufficient number of cases has now been put on record to prove that in some families one or other kind of congenital deformity may be hereditarily transmitted, yet I do not wish it to be supposed that congenital malformations may not arise in individuals in whom no hereditary tendency can be traced. It is undoubtedly true that family histories are in many cases very defective, and frequently cannot be followed back for more than one, or, at the most, two generations; so that it is not unlikely that an hereditary predisposition may exist in many instances where it cannot be proved. Still, allowing even for a considerable proportion of such cases, a sufficient number will remain to warrant the statement that malformations or variations in structure which have not been displayed by their ancestors may arise in individuals belonging to a particular generation.

The variations which I have spoken of as congenital malformations arise, as a rule, before the time of birth, during the early development of the individual; but there is an important class of cases, in which the evidence for hereditary transmission is more or less strong, which may not exhibit their peculiarities until months, or even years, after the birth of the individual. This class is spoken of as Hereditary Diseases, and the structural and functional changes which they produce exercise most momentous influences. Sometimes these diseases may occasion changes in the tissues and organs of the body of considerable magnitude, but at other times the alteration is much more subtle, is molecular in its character, requires the microscope for its determination, or is even incapable of being recognised by that instrument.

Had one been discussing the subject of hereditary disease twenty years ago, the first example probably that would have been adduced would have been tubercu-

[1] Vol. lxxii., Part II., 'Report on the Status of Disease,' p. 1, 1873.
[2] *Liverpool Medico-Chirurg. Journ.*, July 1857; Jan. 1859.

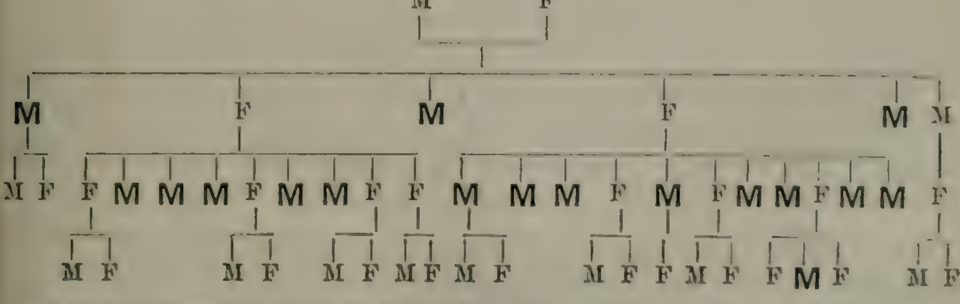
losis, but the additions to our knowledge of late years throw some doubt upon its hereditary character. There can, of course, be no question that tubercular disease propagates itself in numerous families from generation to generation, and that such families show a special susceptibility or tendency to this disease in one or other of its forms. But whilst fully admitting the predisposition to it which exists in certain families, there is reason to think that the structural disease itself is not hereditarily transmitted, but that it is directly excited in each individual in whom it appears by a process of external infection due to the action of the tubercle bacillus. Still, if the disease itself be not inherited, a particular temperament which renders the constitution liable to be attacked by it is capable of hereditary transmission.

Sir James Paget,[1] when writing on the subject of cancer, gives statistics to show that about a quarter of the persons affected were aware of the existence of the same disease in other members of their family, and he cites particular instances in which cancer was present in two and even four generations. He had no doubt that the disease can be inherited—not, he says, that, strictly speaking, cancer or cancerous material is transmitted, but a tendency to the production of those conditions which will finally manifest themselves in a cancerous growth. The germ from the cancerous parent must be so far different from the normal as after the lapse of years to engender the cancerous condition.

Heredity is also one of the most powerful factors in the production of those affections which we call gout and rheumatism. Sir Dyce Duckworth, the latest systematic writer on gout, states that in those families whose histories are the most complete and trustworthy the influence is strongly shown, and occurs in from 50 to 75 per cent. of the cases; further, that the children of gouty parents show signs of articular gout at an age when they have not assumed those habits of life and peculiarities of diet which are regarded as the exciting causes of the disease.

Some interesting and instructive family histories, in which the hereditary transmission of a particular disease through several generations has been worked out, are recorded by Professor Klebs in his 'Allgemeine Pathologie.' I may draw from these one or two additional illustrations. Some families exhibit a remarkable tendency to bleed when the surface of the body is injured or bruised, and the bleeding is stopped with difficulty. The hæmorrhagic tendency is not due to the state of the blood, but to a softening or degeneration of the walls of the blood-vessels, so that they are easily torn. In one family, the tree of which is here subjoined, this peculiarity showed itself in one generation in three out of four males; in the next generation, in thirteen out of fourteen males; whilst in the immediately succeeding generation only one out of nine males was affected; so that it would seem as if the tendency was fading away in it. It is remarkable that throughout the series, though the transmission of the affection went through the female members, they themselves remained free from it.

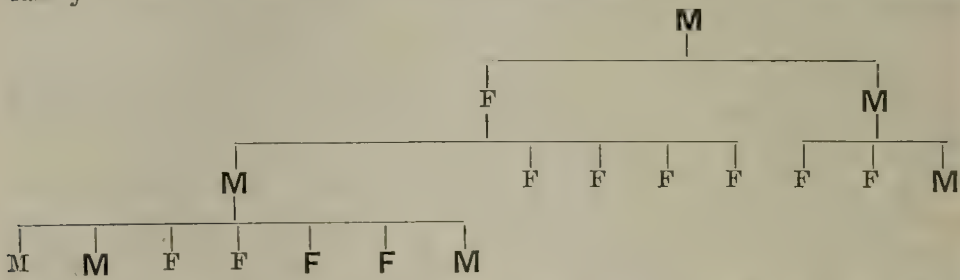
The Family Mampel, recorded by Dr. Lossen.



Another illustration may be taken from the well-known disease of the eyeball

[1] *Lectures on Surgical Pathology*, 3rd ed., revised and edited by the author and W. Turner, London, 1870.

called cataract. Dr. Appenzeller has given an account of a family which exhibited so strong a tendency to this affection that the males were affected in four generations, though the females did not entirely escape, as is shown in the subjoined family tree.



In neither of these families can it be said that the structural lesion itself is transmitted, but that the tendency or predisposition to produce it is inherited. The germ-plasm, therefore, in these individuals must have been so modified from the normal as to carry with it certain peculiarities, and to induce the particular form of disease which showed itself in each family.

In connection with the tendency to the transmissibility of either congenital malformations, or diseases, consanguinity in the parents, although by no means a constant occurrence, is a factor which in many cases must be taken into consideration.[1] If we could conceive both parents to be physiologically perfect, then it may be presumed that the offspring would be so also; but if there be a departure in one parent from the plane of physiological perfection, then it may safely be assumed that either the immediate offspring or a succeeding generation will display a corresponding departure in a greater or less degree. Should both parents be physiologically imperfect, we may expect the imperfections if they are of a like nature to be intensified in the children. It is in this respect, therefore, that the risk of consanguineous marriages arises, for no family can lay claim to physiological perfection.

When we speak of tendencies, susceptibilities, proclivities, or predisposition to the transmission of characters, whether they be normal or pathological, we employ terms which undoubtedly have a certain vagueness. We are as yet quite unable to recognise, by observation alone, in the germ-plasm any structural change which would enable us to say that a particular tendency or susceptibility will be manifested in an organism derived from it. We can only determine this by following out the life-history of the individual. Still it is not the less true that these terms express a something of the importance of which we are all conscious. So far as Man is concerned, the evidence in favour of a tendency to the transmission of both structural and functional modifications which are either of dis-service, or positively injurious, or both, is quite as capable of proof as that for the transmission of characters which are likely to be of service. Hence useless as well as useful characters may be selected and transmitted hereditarily.

I have dwelt somewhat at length on the transmissibility of useless characters, for it is an aspect of the subject which more especially presents itself to the notice of the pathologist and physician; and little, if at all, to that of those naturalists whose studies are almost exclusively directed to the examination of organisms in their normal condition. But when we look at Man, his diseases form so large a factor in his life that they and the effects which they produce cannot be ignored in the study of his nature.

Much has been said and written during the last few years of the transmission from parents to offspring of characters which have been 'acquired' by the parent, so that I cannot altogether omit some reference to this subject. It will conduce

[1] I may especially refer for a discussion of this subject to an admirable essay by Sir Arthur Mitchell, K.C.B., *On Blood Relationship in Marriage considered in its Influence upon the Offspring.*

to one's clearness of perception of this much-discussed question if one defines at the outset in what sense the term 'acquired characters' is employed; and it is the more advisable that this should be done, as the expression has not always been used with the same signification This term may be used in a wide or in a more restricted sense. In its wider meaning it may cover all the characters which make their first appearance in an individual, and which are not found in its parents, in whatever way they have arisen :—

1st. Whether their origin be due to such molecular changes in the germ-plasm as may be called spontaneous, leading to such an alteration in its character as may produce a new variation; or,

2nd. Whether their origin be accidental, or due to habits, or to the nature of the surroundings, such as climate, food, &c.

Professor Weismann has pointed out with great force the necessity of distinguishing between these two kinds of 'acquired characters,' and he has suggested two terms the employment of which may keep before us how important it is that these different modes of origin should be recognised. Characters which are produced in the germ-plasm itself by natural selection, and all other characters which result from this latter cause, he names *blastogenic.* He further maintains that all blastogenic characters can be transmitted; and in this conclusion, doubtless, most persons will agree with him. On the other hand, he uses the term *somatogenic* to express those characters which first appear in the body itself, and which follow from the reaction of the *soma* under direct external influences. He includes under this head the effects of mutilation, the changes which follow from increased or diminished performance of function, those directly due to nutrition, and any of the other direct external influences which act upon the body. He further maintains that the somatogenic characters are not capable of transmission from parent to offspring, and he suggests that in future discussions on this subject the term 'acquired characters' should be restricted to those which are somatogenic.

Thus one might say that blastogenic characters arising in the germ would be acquired in the individual by the action of the germ upon the soma; so that if we return again to the graphic illustration previously employed, the germ-plasm represented by the small italic letters *abcd* would act upon the soma represented by the capital letters A, B, C, D. Somatogenic characters, again, arising in the soma, would be acquired by the action of the soma A, B, C, D, upon the contained germ-plasm *abcd.* But whether those acquired characters expressed by the term somatogenic can or can not be transmitted has been fruitful of discussion.

That the transmission of characters so acquired can take place is the foundation of the theory of Lamarck, who imagined that the gradual transformation of species was due to a change in the structure of a part of an organism under the influence of new conditions of life, and that such modifications could be transmitted to the offspring. It was also regarded as of importance by Charles Darwin, who stated [1] that all the changes of corporeal structure and mental power cannot be exclusively attributed to the natural selection of such variations as are often called spontaneous, but that great value must be given to the inherited effects of use and disuse, some also to the modification in the direct and prolonged action of changed conditions of life, also to occasional reversions of structure. Herbert Spencer believes [2] that the natural selection of favourable varieties is not in itself sufficient to account for the whole of organic evolution. He attaches a greater importance than Darwin did to the share of use and disuse in the transmission of variations. He believes that the inheritance of functionally produced modifications of structure takes place universally, and that as the modification of structure by function is a *vera causa* as regards the individual, it is unreasonable to suppose that it leaves no traces in posterity.

On the other hand, there are very eminent authorities who contend that the somatogenic acquired characters are not transmissible from parent to offspring. Mr. Francis Galton, for example, gives a very qualified assent to the possibility of

[1] Preface to 2nd edition of *Descent of Man*, 1885; also *Origin of Species*, 1st ed.
[2] 'Factors of Organic Evolution,' *Nineteenth Century*, 1886.

transmission. Professor His, of Leipzig, doubts its validity. Professor Weismann says that there is no proof of it. Mr. Alfred Russel Wallace, in his most recent work,[1] considers that the direct action of the environment, even if we admit that its effects on the individual are transmitted by inheritance, are so small in comparison with the amount of spontaneous variation of every part of the organism that they must be quite overshadowed by the latter. Whatever other causes, he says, have been at work, natural selection is supreme to an extent which even Darwin himself hesitated to claim for it.

There is thus a conflict of opinion amongst the authorities who have given probably the most thought to the consideration of this question. It may appear, therefore, to be both rash and presumptuous on my part to offer an opinion on this subject. I should, indeed, have been slow to do so had I not thought that there were some aspects of the question which seemed not to have been sufficiently considered in its discussion.

In the first place, I would, however, express my agreement with much that has been said by Professor Weismann on the want of sufficient evidence to justify the statement that a mutilation which has affected a parent can be transmitted to the offspring. It is, I suppose, within the range of knowledge of most of us that children born of parents who have lost an eye, an arm, or a leg come into the world with the full complement of eyes and limbs. The mutilation of the parent has not affected the offspring; and one would, indeed, scarcely expect to find that such gross visible losses of parts as take place when a limb is removed by an accident or a surgical operation should be repeated in the offspring. But a similar remark is also applicable to such minor mutilations as scars, of the transmission of which to the offspring, though it has been stoutly contended for by some, yet seems not to be supported by sufficiently definite instances.

I should search for illustrations of the transmission of somatogenic characters in the more subtle processes which affect living organisms, rather than those which are produced by violence and accident. I shall take as my example certain facts which are well known to those engaged in the breeding of farm-stock or of other animals that are of utility to or are specially cultivated by man.

I do not refer to the influence on the offspring of impressions made on the senses and nervous system of the mother, the first statement of the effects of which we find in the book of Genesis, where Jacob set peeled rods before the flocks in order to influence the colour and markings of their young; though I may state that I have heard agriculturists relate instances from their own experience which they regarded as bearing out the view that impressions acting through the mother do influence her offspring. But I refer to what is an axiom with those who breed any particular kind of stock, that to keep the strain pure, there must be no admixture with stock of another blood. For example, if a shorthorned cow has a calf by a Highland sire, that calf, of course, exhibits characters which are those of both its parents. But future calves which the same cow may have when their sires have been of the shorthorned blood, may, in addition to shorthorn characters, have others which are not shorthorned but Highland. The most noteworthy instance of this transmission of characters acquired from one sire through the same mother to her offspring by other sires is that given in the often-quoted experiment by a former Lord Morton.[2] An Arabian mare in his possession produced a hybrid the sire of which was a quagga, and the young one was marked by zebra-like stripes. But the same Arabian had subsequently two foals, the sire of which was an Arab horse, and these also showed some zebra-like markings. How, then, did these markings characteristic of a very different animal arise in these foals, both parents of which were Arabians? I can imagine it being said that this was a case of reversion to a very remote striped ancestor, common alike to the horse and the quagga. But, to my mind, no such far-fetched and hypothetical explanation is necessary. The cause of the appearance of the stripes seems to me to be much

[1] *Darwinism*, p. 443; London, 1889.

[2] *Philosophical Transactions*, 1881; also Darwin's *Animals and Plants under Domestication*, first ed. vol. i. p. 403, 1868.

nearer and more obvious. I believe that the mother had acquired during her prolonged gestation with the hybrid, the power of transmitting quagga-like characters from it, owing to the interchange of material which had taken place between them in connection with the nutrition of the young one. For it must be kept in mind that in placental mammals an interchange of material takes place in opposite directions, from the young to the mother as well as from the mother to the young.[1] In this way the germ-plasm of the mother, belonging to ova which had not yet matured, had become modified whilst still lodged in the ovary. This acquired modification had influenced her future offspring, derived from that germ-plasm, so that they in their turn, though in a more diluted form, exhibited zebra-like markings. If this explanation be correct, then we have an illustration of the germ-plasm having been directly influenced by the soma, and of somatogenic acquired characters having been transmitted.

But there are other facts to show that the isolation of the germ-cells or germ-plasm from the soma cells is not so universal as might at the first glance be supposed. Weismann himself admits that in the Hydroids the germ-plasm is present in a very finely divided, and therefore invisible, state in certain somatic cells in the beginning of embryonic development, and that it is then transmitted through innumerable cell generations to those remote individuals of the colony in which sexual products are formed. The eminent botanist Professor Sachs states that in the true mosses almost any of the cells of the roots, leaves, and shoot axes may form new shoots and give rise to independent living plants. Plants which produce flowers and fruit may also be raised from the leaves of the *Begonia*. I may also refer to what is more or less familiar to everybody, that the tuber of the potato can give rise to a plant which bears flowers and fruit. Now in these cases the germ-plasm is not collected in a definite receptacle isolated from the soma, but is diffused through the cells of the leaves of the Begonia or amidst those of the tuber of the potato, and the propagation of the potato may take place through the tuber for several generations without the necessity of having to recur to the fruit for seed. It seems difficult, therefore, to understand why, in such cases, the nutritive processes which affect and modify the soma cells should not also react upon the germ-plasm, which, as Weismann admits, is so intimately associated with them.

Those who uphold the view that characters acquired by the soma cannot be transmitted from parents to offspring undoubtedly draw so large a cheque on the bank of hypothesis that one finds it difficult, if not impossible, to honour it. Let us consider for one moment all that is involved in the acceptance of this theory, and apply it in the first instance to Man. On the supposition that all mankind have been derived from common ancestors through the continuity of the germ-plasm, and that this plasm has undergone no modification from the *persona* or *soma* of the succession of individuals through whom it has been transmitted, it would follow that the primordial human germ-plasm must have contained within itself an extraordinary potentiality of development—a potentiality so varied that all the multiform variations in physical structure, tendency to disease, temperament, and other characters and dispositions which have been exhibited by all the races and varieties of men who either now inhabit or at any period in the world's history have inhabited the earth, must have been included in it. But if we are to accept the theory of Natural Selection, as giving a valid explanation of the origin of new species, then the non-transmissibility of somatogenic acquired characters has a much more far-reaching significance. For if all the organisms, whether vegetable, animal, or human, which have lived upon the earth have arisen by a more or less continuous process of evolution from one or even several simple cellular organisms, it will follow as a logical necessity of the theory of the non-transmission of acquired characters, that these simple organisms must have contained in their molecular constitution a potentiality of evolution into higher and more complex forms of life, through the production of variations, without the inter-

[1] See, for facts and experiments, *Essays*, by Professors Harvey and Gusserow and Mr. Savory; also my *Lectures on the Comparative Anatomy of the Placenta*, Edinburgh, 1876.

mediation of any external force or influence acting directly upon the soma. Further, this must have endured throughout a succession of countless individual forms and species, extending over we know not how many thousands of years, and through the various geological and climatic changes which have affected the globe.

The power of producing these variations would therefore, on this theory, have been from the beginning innate to the germ-plasm, and uninfluenced in any way by its surroundings. Variations would have arisen spontaneously in it, and, for anything that we know, as it were by accident, and without a definite purport or object. But whether such variations would be of service or dis-service could not be ascertained until after their appearance in the soma had subjected them to the test of the conditions of life and the environment.

Let us now glance at the other side of the question. All biologists will, I suppose, accept the proposition that the individual soma is influenced or modified by its environment or surroundings. Now, if on the basis of this proposition the theory be grafted that modifications or variations thus produced are capable of so affecting the germ-plasm of the individual in whom the variation arises as to be transmitted to its offspring—and I have already given cases in point—then such variations might be perpetuated. If the modification is of service, then presumably it will add to the vitability of the individual, and through the interaction between the soma and the germ-plasm, in connection with their respective nutritive changes, will so affect the latter as to lead to its being transmitted to the offspring. From this point of view the environment would, as it were, determine and regulate the nature of those variations which are to become hereditary, and the possibility of variations arising which are likely to prove useful becomes greater than on the theory that the soma exercises no influence on the germ-plasm. Hence I am unable to accept the proposition that somatogenic characters are not transmitted, and I cannot but think that they form an important factor in the production of hereditary characters.

To reject the influence which the use and disuse of parts may exercise both on the individual and on his offspring is like looking at an object with only a single eye. The morphological aspect of organic structure is undoubtedly of fundamental importance. But it should not be forgotten that tissues and organs, in addition to their subjection to the principles of development and descent, have to discharge certain specific purposes and functions, and that structural modifications arise in them in correlation with the uses to which they are put, so as to adapt them to perform modified duties. It may be difficult to assign the exact value which physiological adaptation can exercise in the perpetuation of variations. If the habit or external condition which has produced a variation continues to be practised, then, in all probability, the variation would be intensified in successive generations. But should the habit cease or the external condition be changed, then, although the variation might continue to be for a time perpetuated by descent, it would probably become less strongly marked and perhaps ultimately disappear. One could also conceive that the introduction of a new habit or external condition the effect of which would be to produce a variation in a direction different from that which had originally been acquired, would tend to neutralise the influence of descent in the transmission of the older character.

By accepting the theory that somatogenic characters are transmitted we obtain a more ready explanation, how men belonging to a race living in one climate or part of the globe can adapt themselves to a climate of a different kind. On the theory of the non-transmissibility of these acquired characters, long periods of years would have to elapse before the process of adaptation could be effected. The weaker examples, on this theory, would have had to have died out, and the racial variety would require to have been produced by the selection of variations arising slowly, and requiring one knows not how many hundreds or thousands of years to produce a race which could adapt itself to its new environment. We know, however, that this process of the dying out of the weakest and the selection of the strongest is not necessary to produce a race which possesses well-recognisable physical characters. For most of us can, I think, distinguish the nationality of a

citizen of the United States by his personal appearance, without being under the necessity of waiting to hear his speech and intonation.

It may perhaps be thought, in selecting the subject of Heredity for my address, and in treating it as I have to a large extent done, in its general biological aspects, that I have infringed upon the province of Section D. But I am not prepared to admit that any such encroachment has been made. Man is a living organism, with a physical structure which discharges a variety of functions, and both structure and functions correspond in many respects, though with characteristic differences, with those which are found in animals. The study of his physical frame cannot therefore be separated from that of other living beings, and the processes which take place in the one must also be investigated in the other. Hence we require, in the special consideration of the physical framework of Man, to give due weight to those general features of structure and functions which he shares in common with other living organisms. But whatever may have been the origin of his frame, whether by evolution from some animal form or otherwise, we can scarcely expect it ever to attain any greater perfection than it at present possesses.

The physical aspect of the question, although of vast importance and interest, yet by no means covers the whole ground of Man's nature, for in him we recognise the presence of an element beyond and above his animal framework.

Man is also endowed with a spiritual nature. He possesses a conscious responsibility which enables him to control his animal nature, to exercise a discriminating power over his actions, and which places him on a far higher and altogether different platform than that occupied by the beasts which perish. The kind of evolution which we are to hope and strive for in him is the perfecting of this spiritual nature, so that the standard of the whole human race may be elevated and brought into more harmonious relation with that which is holy and divine.

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3. *On the Early Failure of pairs of Grinding-Teeth.* *By* W. Wilberforce Smith, *M.D., M.R.C.P. Lond.*

The author gave the results of the examination of 153 persons—all dwellers in London, and composed of shopwomen, of physician's out-patients, and of a group of young men forming a mutual improvement society.

These results, tabulated below, tend to indicate that when the grinding-teeth, premolars, and molars are considered as opponent pairs, the average loss is far greater than casual observation of the front of the mouth would be likely to suggest, and that it progresses rapidly in young adults, *pari passu* with age, which is the essential modifying condition.

The loss is much greater in molar than in premolar pairs of teeth, just as premolars are in their turn more liable than front teeth (canines and incisors).

These facts may be compared with various others tending to the conclusion that the lessened wear and friction in the grinding-teeth of civilised races is a predisposing cause of decay.

Pairs of Molars.

Age	No. of persons examined	Retained	Lost
15–30	75	(5 circ. Normal) 2·20 average	56 per cent.
	Comprising 45 shopwomen	2·14 "	
	Comprising 23 out-patient women	2·13 "	
	Comprising 7 " " men		
30–50	40	(6 Normal) 1·07 average	82·6 per cent.
	Comprising 24 out-patient women	1·01 "	
	Comprising 8 shopwomen		
	Comprising 8 out-patient men		

Pairs of Molars.—continued.

Age	No. of persons examined	Retained	Lost
15–20	27 Comprising { 23 shopwomen 4 out-patients	(4 or + Normal) 2·15 average 2·19 „	46·2 per cent.
20–25	27 Comprising { 12 shopwomen 12 out-patient women 3 „ „ men	(5 circ. Normal) 2·04 average 1·79 „ 2·05 „	59·2 per cent.
25–30	21 Comprising { 10 shopwomen 9 out-patient women 2 „ „ men	(6 Normal) 2·47 average 2·45 „ 2·16 „	58·8 per cent.
30–40	20 Comprising { 7 shopwomen 9 out-patient women 4 „ „ men	1·40 average	76·6 per cent.
40–50	20 Comprising { 15 out-patient women 4 „ „ men 1 shopwoman	·75 average ·80 „	87·5 per cent.
50–70	12 Comprising { 10 out-patient women 2 „ „ men	·66 average	89 per cent.

Pairs of Premolars.

Age	No. of persons examined	Retained	Lost
15–20	23 shopwomen	(4 Normal) 3·18 average	20·5 per cent.
20–30	22 shopwomen	2·35 average	41·2 per cent.

Pairs of Molars with Premolars.

Age	No. of persons examined	Retained	Lost
15–20	30 Comprising { 23 shopwomen 7 evening-class men	(8 or + Normal) 5·57 average 5·37 „	31·1 per cent.
20–25	26 Comprising { 12 shopwomen 14 evening-class men	(9 circ. Normal) 4·52 average 4·35 „ 4·67 „	49·7 per cent.
25–30	26 Comprising { 10 shopwomen 5 evening-class men	(10 Normal) 4·04 average 4·56 „	59·6 per cent.

4. *Note on the Development of the Wisdom-Teeth.* *By* RIDOLFO LIVI, *M.D.*

In January and December 1885, and in November 1886, when I was visiting the conscripts born in the years 1864, 1865, and 1866, in the military districts of Monza (Lombardy) and Ancona (Marche), at the time of their arrival at the regiment, I took notice of the development of the wisdom-teeth.

In so short a time as that ordinarily devoted to such visits I was able to note only the number of the teeth existing in each mouth, without calculating their respective position in the dental arch. Yet even this simple observation—if combined with others that the military surgeon in Italy is by regulation obliged to make—may lead to some useful result on this point, the importance of which in the question of the hierarchy of the human races was first divined by the great Darwin.

The total number of individuals examined was 732; namely, 366 natives of the military district of Monza (Lombardy) and 366 of the military district of Ancona (Marche). Their average age, calculated according to the above dates, was twenty years and five months. The two groups are divided as follows in regard to the number of the wisdom-teeth:—

TABLE I.

Number of the wisdom-teeth	Lombards			Marchigiani			Total		
	Number of cases	Proportion %	Total of wisdom-teeth	Number of cases	Proportion %	Total of wisdom-teeth	Number of cases	Proportion %	Total of wisdom-teeth
0	173	47·3	—	155	42·4	—	328	44·8	—
1	43	11·7	43	48	13·1	48	91	12·4	91
2	61	16·7	122	67	18·3	134	128	17·5	256
3	30	8·2	90	22	6·0	66	52	7·1	156
4	59	16·1	236	74	20·2	296	133	18·2	532
Total	366	100·0	491	366	100·0	544	732	100·0	1,035
Average number of wisdom-teeth in each individual	1·34			1·49			1·41		

I must note here the small number of individuals who have an odd number of wisdom-teeth. This is evidently a consequence of the fact that the wisdom-teeth appear generally two by two. According to the observations of Magitot[1] the superior teeth should be the first to appear.

The relation between the number of wisdom-teeth and the height is shown in Tables II. and III.:—

TABLE II.

Districts of birth	Average height of the conscripts with—			General average height	Average number of the wisdom-teeth
	No wisdom-teeth	1 or 2 wisdom-teeth	3 or 4 wisdom-teeth		
	mètres	mètres	mètres	mètres	
Monza (Lombardy) .	1·637	1·642	1·661	1·646	1·34
Ancona (Marche). .	1·619	1·619	1·631	1·622	1·49
Total . .	1·628	1·630	1·645	1·634	1·41

[1] *Bulletin de la Société d'Anthropologie de Paris ; Séance du* 20 *Février*, 1879 (p. 156).

In Table II. is indicated the average height of the conscripts according as they have either no wisdom-teeth at all, or one and two, or three and four.

TABLE III.

Districts of birth	Individuals with a height of— Mètres 1·70 and more: Number of cases	Mètres 1·70 and more: Average number of the wisdom-teeth	Mètres 1·60 and less: Number of cases	Mètres 1·60 and less: Average number of the wisdom-teeth
Monza (Lombardy) . .	61	1·90	69	1·01
Ancona (Marche) . .	19	1·95	125	1·35
Total . . .	80	1·91	194	1·23

Table III. shows the average number of the wisdom-teeth in the individuals of great stature and in those of lower height.

If we consider only the general average height (Table II.) we should conclude that the less the number of wisdom-teeth the more elevated is the height. But a more careful analysis shows instead that the height sensibly increases in direct proportion to the number of teeth. Certainly this is not caused by a direct influence of the height upon the number of the wisdom-teeth, but rather is it owing to the fact that at twenty years and a half neither the evolution of the teeth nor that of the height is complete, and we may hold that the conscripts with few or no wisdom-teeth, who are of a lower height than the others, are just those whose general development has been delayed in consequence of various disturbing influences.

Let us observe also that the difference of height between the conscripts with no teeth and those with three or four is greater among the Lombards than among the Marchigiani. It most probably signifies that the Marchigiani are nearer than the Lombards to their definitive height. In fact, we know even from other studies [1] that in the Italians of the north the growth from sixteen to twenty years is less rapid than in those of the south, and that the epoch of menstruation and of puberty comes later.

I have endeavoured also to discover whether the social condition of the conscripts may have some influence on the number of the wisdom-teeth. The 704 individuals of whose profession I was aware are classed in the Table IV. according to their being either agriculturalists, artisans, or possidents, students, tradesmen and professional men.

TABLE IV.

Districts of birth	Agricultors: Number of cases	Agricultors: Total number of the wisdom-teeth	Agricultors: Average individual number of the wisdom-teeth	Artisans: Number of cases	Artisans: Total number of the wisdom-teeth	Artisans: Average individual number of the wisdom-teeth	Possidents, students, tradesmen, &c.: Number of cases	Possidents, students, tradesmen, &c.: Total number of the wisdom-teeth	Possidents, students, tradesmen, &c.: Average individual number of the wisdom-teeth
Monza (Lombardy) .	182	235	1·29	156	221	1·42	13	10	0·77
Ancona (Marche) .	217	309	1·42	114	187	1·64	22	35	1·59
Total . . .	399	544	1·36	270	408	1·51	35	45	1·29

[1] Rascri: *Materiali per la Etnologia Italiana, Annali di Statistica*, Serie II., vol. 8°, Roma, 1879.

TABLE V.

Number of wisdom-teeth	Monza (Lombardy) Cephalic index = 83·9 Examined individuals, 366						Ancona (Marche) Cephalic index = 83·8 Examined individuals, 365 [1]						Total Examined individuals, 731					
	Under the average cephalic index			Above the average cephalic index			Under the average cephalic index			Above the average cephalic index			Under the average cephalic index			Above the average cephalic index		
	Number of cases	Proportion %	Number of the wisdom teeth	Number of cases	Proportion %	Number of the wisdom teeth	Number of cases	Proportion %	Number of the wisdom teeth	Number of cases	Proportion %	Number of the wisdom teeth	Number of cases	Proportion %	Number of the wisdom teeth	Number of cases	Proportion %	Number of the wisdom teeth
0	84	44·9	—	89	49·7	—	71	37·4	—	84	48·0	—	155	41·1	—	173	48·9	—
1	19	10·1	19	24	13·4	24	29	15·3	29	19	10·9	19	48	12·7	48	43	12·1	43
2	28	15·0	56	33	18·4	66	40	21·0	80	27	15·4	54	68	18·0	136	60	17·0	120
3	17	9·1	51	13	7·3	39	13	6·8	39	9	5·1	27	30	8·0	90	22	6·2	66
4	39	20·9	156	20	11·2	80	37	19·5	148	36	20·6	144	76	20·2	304	56	15·8	224
Totals	187	100·0	282	179	100·0	209	190	100·0	296	175	100·0	241	377	100·0	578	354	100·0	453
Average individual number of the wisdom-teeth	1·51			1·17			1·56			1·39			1·53			1·28		

[1] Here are noted only 365 Marchigiani instead of 366, as in the other tables, because the cephalic index of one was not measured.

We observe that in both districts the countrymen present a slower development of the wisdom-teeth, and this agrees with the more unfavourable conditions of nutrition and harder life to which the countrymen in Italy are exposed compared with the town people. As to the liberal professions, the number of observations is perhaps too small to permit one to deduce from them considerations of much value.

In conclusion, it appears from these slight inquiries that the evolution of the wisdom-teeth proceeds in conformity with the general development of the body, and that the favourable or unfavourable circumstances which modify the latter may accelerate or delay the former.

I should have wished also to measure the facial angle of each individual observed, in order to see the relation between the prognathism and the development of the wisdom-teeth. We may yet make use of the cephalic index, for we know the direct relation which exists between this cranial character and the facial angle. Not only are the brachycephalic races generally the most ortognathous, but dolichocephaly grows in the same race in direct conformity with the prognathism.

The cephalic index of the 366 Lombards was 83·9; that of the 366 Marchigiani 83·8.

Here the index is almost the same. But if we divide each group into two parts, one composed of those who have a higher index, the other composed of those who have a lower index than the average one, we shall find remarkable differences.

We then see that in both groups dolichocephaly seems to favour the development of the wisdom-teeth,[1] which may be explained by the greater extension of the dental arch, *i.e.*, by the greater prognathism.

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5. *Left-leggedness.* *By* W. K. Sibley, *M.B.*

Professor Ball in 'Le Dualisme Cérébral' speaks of man as a right-handed animal. Being right-handed, it is popularly assumed that he is also right-legged; but this does not appear to be the case. Standing working with the right hand there is a tendency to use the left leg for balance. Many people find less exertion in going round circles to the right than to the left; race-paths are nearly always made for running in circles to the right. So the majority of movements are more readily performed to the right, as dancing, running, &c. The rule in walking is to keep to the right, and this appears to be almost universal. It is more natural to bear to the right. Of a large number of people from the better-educated classes asked about the existence of the rule, only 67 per cent. males and 53 per cent. females were aware of the rule; the large majority obey it unconsciously in walking. Crowds tend to bear to the right. The left leg being the stronger, it is more readily brought into action; hence troops start off with the left foot; it is the foot which is placed into the stirrup of the saddle or step of bicycle in mounting; so the left is the foot which a man takes off from in jumping. The experiments of Mr. G. H. Darwin blind-folding boys and telling them to walk straight, the right-handed ones diverged to the right, and *vice versâ*. From measurements of Dr. Garson of the skeletons of the two legs, 54·3 per cent., the left was the longer and 35·8 the right.[2] For measurements of the feet the author collected the drawings and measurements of 200 pairs, for which he is indebted to the courtesy of Mr. Parker of Oxford Street, with the result that in 44 per cent. the left was longer, in 21·5 per cent. the right, and in 34·5 per cent. they were the same size. Measurement at the first joint gave 56 per cent. left larger, and at the instep 42·5 per cent. From the table of the figures it is observed that the left foot is more frequently the larger in the male than female sex, and the percentage of feet of the same size is greater in the female. The percentage of the right larger than the left is very constant, whereas the numbers of the left larger and those in which both feet were the same size are much more variable.

[1] Even Mantegazza (*Bulletin de la Société d'Anthropologie de Paris; Séance du 20 Juin*, 1878) says that among the Romagnoli, who are greatly brachycephalic, he observed the frequent absence of the wisdom-teeth.

[2] Ten per cent. being of the same size.

Man, being naturally or artificially right-handed and left-legged, tends unconsciously to bear to the right; lower animals, on the other hand, appear nearly always to circle to the left.

Table showing Difference in the Size of the Feet.

(A) Percentage of 150 males.
(B) Percentage of 50 females.
(C) Percentage of 200 mixed cases.

		Length	First Joint	Instep	Heel
Left larger	A	48	59	43	44·5
	B	38	50	40	16
	C	44	56	42·5	33
Right larger	A	22	24	28·5	34
	B	20	24	22	34
	C	21·5	24	26·5	36·5
Same size	A	30	17	26·5	21·5
	B	42	26	38	50
	C	34·5	20	30	30·5

6. *The Occasional Eighth True Rib in Man, and its possible relationship to Right-handedness.*[1] *By* Professor D. J. Cunningham, *M.D.*

Professor Cunningham referred to the occasional presence of an eighth true rib in man, and gave statistics upon this point, which had been obtained for him by his assistant, Mr. O. L. Robinson. In seventy subjects examined the anomaly occurred fourteen times—*i.e.*, in 20 per cent. It was found twice in the male for every once in the female. Five cases were bilateral; nine cases were unilateral, and of these no less than eight exhibited the anomaly on the right side. From this Professor Cunningham considered that it was just possible that the anomaly might have some connection with right-handedness.

7. *The Proportion of Bone and Cartilage in the Lumbar Section of the Vertebral Column in the Ape and different races of Men.*[1] *By* Professor D. J. Cunningham, *M.D.*

With the assumption of the erect attitude the bodies of the lumbar vertebræ and the intervertebral discs in the human spine have become much modified. In the majority of the quadrupeds the bodies of the lumbar vertebræ are long, narrow, and rod-like; in man they are short, broad, and disc-like. The change from the one form to the other is not sharp and sudden, but can be traced as a gradual process through the apes up to man. Sexual differences, racial differences, and age differences in the relative length of the bodies of the lumbar vertebræ are also apparent. The amount of cartilage stands in inverse ratio to the amount of bone. Where the vertebræ are relatively long, the cartilage is small in amount; where the bones are relatively short, the cartilage is more abundant. This clearly is a provision for the deadening of shocks transmitted in an upward direction through the erect spine of man and the semi-erect spines of certain of the apes.

8. *Exhibition of the Model of the Head of a Man stated to be* 106 *years old, with the Brain exposed in situ. By* Professor D. J. Cunningham, *M.D.*

[1] Printed in full in the *Journal of Anatomy and Physiology* for October, 1889.

9. *Exhibition of the Model of the Head and Shoulders of a young Orang Utan, with the Brain exposed in situ. By* Professor D. J. CUNNINGHAM, *M.D.*

FRIDAY, SEPTEMBER 13.

The following Papers and Report were read :—

1. *Hypothesis of a European Origin of Early Egyptian Art. By the* Rev. J. WILSON, *M.A.*

Egyptian art had reached a high degree of perfection at the beginning of the First Empire. In Egypt, as elsewhere, art was not full-grown at birth.

Centuries, perhaps millenniums, of previous progress were necessary ere statues such as that of the cross-legged Scribe in the Bulak Museum could have been executed. Where was art thus gradually matured in the centuries before Menes? Not necessarily in Egypt, since in early times the nation was composite. Can archæology point to any palæolithic race endowed with the promise of high artistic skill? Only one, viz., the so-called Cro-Magnon race of South-western France. MM. Zabovowski and Broca were quoted as to the importance of the traces of incipient art in the hands of this race.

Their drawings on plates of ivory, bone, &c., of the mammoth, as well as the reindeer and antelope, are sufficient proofs of the vast antiquity of that race, which lived in the transition age between the period of the mammoth and of the reindeer.

What connection can be shown to have existed between this race and early Egypt?

Ethnologists, such as Virchow, Sayce, Maspero, agree that a leading element in the old Egyptian Empire was a white race, and some recent Egyptologists refer this white element to the Mediterranean race which belonged to the stock called by French archæologists the Cro-Magnon race. Comparison between the Mediterranean or Cro-Magnon race and the Egyptians of the First Empire as to physical characteristics.

Extension of the later representatives of the Cro-Magnon race southwards to the Mediterranean islands, the Canaries, and North Africa, owing to geological and climatic changes. The transit to Africa would be easy at a period when North-western Africa was still joined with Spain. This southward migration—at least as to its later waves—coincided with the incoming of a new race, the dolmen-builders, who passing, at least immediately, from Northern Europe, became mixed with the Cro-Magnon race in France and Spain, and passed into North Africa, where they were represented by the white *Thahennu* of the Egyptian sculptures and by the modern Kabyles of Algeria. The old artistic talent of the Cro-Magnon race nowhere reappeared (except in Egypt), because the cultivation of art requires certain favouring conditions which were found in perfection in Egypt. As to whether the European invasion of North Africa took place at a period considerably earlier than the dawn of the First Empire [evidences adduced]. What evidence is there that this invading European race overran Egypt? Besides the traces of a common race-type between them and the earliest Egyptians, we have the fact of invasions of Egypt by branches of the Mediterranean race within the historic period and facts indicating that in prehistoric times this race had traversed the Nile Valley. Further, the political state of Egypt before Menes, as indicated by tradition, agrees with our hypothesis of a warlike northern race ruling a subject population.

Next inquire how far the earliest Egyptian architecture agrees in type with that of the prehistoric European invaders. Can the former be conceived as identical with the latter, though at a higher stage of development?

Character of the North African megalithic structures compared with that of the earliest Egyptian buildings.

Governing ideas common to the sepulchral architecture of prehistoric Western Europe and of early Egypt.

Method of protecting the abode of the dead from violation.

The tomb considered as the dwelling-place of the dead, or his 'double.'

Necessity of distinguishing the rank of the dead by the size of his sepulchre.

Summary of points of resemblance between the pyramids and the great chambered tumuli of Europe.

Analogies between early Egypt and prehistoric Europe in regard to other arts and customs.

One reason makes it probable that the less civilised northern invaders of Egypt, while adopting the civilisation of that country, would conserve their own form of sepulchral architecture.

What must we make of certain curious analogies between the agriculture of neolithic Europe and of early Egypt?

Analogy between curious sculptured figures in the caves of Marne with certain Egyptian divinities.

The absence of linguistic affinity between Egypt and prehistoric Europe does not militate against our hypothesis.

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2. *African Airs and Musical Instruments.* *By* His Excellency Governor Moloney, *C.M.G.*

The author distributed the airs geographically as follows:—A, Gambia; B, Ewe or Dahomey; C, Yoruba; and D, Houssa.

In the first division specimens were given of *Bambara, Mandingo,* and *Volof* melodies, while *Popo* and *Dahomey* airs illustrated section B. The *Yoruba* division included *Lagos, Ibadan,* and other airs, and reference was made to several *Houssa* melodies.

These countries were topographically described, and brief reference was made to their musical instruments and to the native minstrels. The paper concluded with an explanation of what is known as the '*drum-language.*'

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3. *The Vikings, the Direct Ancestors of the English-speaking Nations.* *By* Paul B. Du Chaillu.

The author described the early civilisation and antiquities of the Northmen, and dwelt upon the beauty of their ornaments and weapons, and also upon the similarity of Scandinavian and English ornaments belonging to the early iron age, and the love of the Northern people for the sea. He spoke of the three maritime tribes of the north, according to the Romans, and of the fleets of the Suecones in the time of Tacitus; of the expeditions of the so-called Saxons and Franks, and of the home of these tribes; of the proofs from antiquities found in the North of the commerce of the Northmen with the Roman Empire and with Greece, and also pointed out that the tribes of Germania were not a seafaring people, and were uncivilised, according to Roman writers. He gave an account of the probable origin of the names 'Saxon' and 'Frank,' and spoke of the early settlements in Britain by the Northmen during the Roman occupation, and of how the name of England might have been given to part of Britain. He alluded to the different countries of the Jutes, and how the language of the North and that of England was similar in early times, and that England was always called by the Northmen one of the Northern lands, and of the early Northern kings who claimed to own part of England. He mentioned the English and Frankish chronicles, in which the Suecones, Danes, and Northmen are described, and that neither Saxons nor Franks were a seafaring people either at the time of Charlemagne or at any earlier period, and he dwelt on the mythical settlement of Britain by Hengist and Horsa, given by the English chronicles, which is quite contrary to the Roman records, Sagas, and archæology, and concluded by showing that the Northmen, or Vikings, were the direct ancestors of the English people.

4. *Further Researches as to the Origin of the Aryans.*[1] *By* Canon ISAAC TAYLOR, *Litt.D., LL.D.*

The author began by briefly referring to the paper on the subject which two years ago he read at the Manchester meeting of the British Association. In that paper he gave an account of the history of opinion during the last fifty years, and showed that, while the scholars of the last generation were nearly unanimous in thinking that the Aryans had migrated from Asia, there was now an equally pronounced tendency to believe that they had originated in Europe. He also stated his own belief that the fundamental agreement between the Aryan and Ugro-Finnic languages, both in their grammatical structure and their verbal roots, could only be explained by the hypothesis that Aryan speech had been evolved out of some language of the Ugro-Finnic class.

This paper had been met by the argument that the physical type of the Ugro-Finnic race was so wholly different from that of the Aryans that it was impossible to believe that the one could be connected with the other by descent. German scholars, more especially Pösche and Penka, had contended that the primitive Aryans belonged to the tall, fair, blue-eyed, and dolicho-cephalic type, now represented by the Scandinavians and North Germans; while French writers were inclined to the belief that the primitive Aryans were short, swarthy, black-eyed, and brachy-cephalic. The Germans, in short, claimed the primitive Aryans as typical Germans; the French claimed them as typical Frenchmen. Each accused the other of subordinating the results of science to Chauvinistic sentiment. A controversy had arisen in the *Times*, in which Sir John Lubbock and Professor Bryce had taken a prominent part, as to the race-type of our own islands, the issue of which seemed to be that in Great Britian both types are found in not unequal proportions. Englishmen therefore may claim to be able to discuss the question of the race-type of the Aryans without being biassed by Chauvinistic prejudices.

The author said that, under these circumstances, he had now re-examined the whole question from the anthropological rather than from the philological point of view.

Assuming that there had been no migration of any new race into Europe since the neolithic period, he contended that anthropologists have established the existence in Europe of four distinct prehistoric raçes, which might be reasonably connected with four existing types, which occupied nearly the same regions as the four prehistoric races.

We have:—

(1.) The tall Northern dolicho-cephalic race, the Canstadt race of De Quatrefages, which is the Scandinavian race of Penka, and the Eguisheim race of other writers. It is represented by the Stængenæs skeleton discovered by Nilsson in a shell mound in Sweden, and may probably be identified with the race of the Danish kitchen middens. The stature of this race amounted to 5 feet 10 inches. It was platy-cephalic, prognathous, and dolicho-cephalic, with a mean cephalic index of from 70 to 73. This is the race which, somewhat modified in its extreme characteristics during the lapse of ages, is represented in Burgundian, Frankish, and Anglo-Saxon tombs, and is to be identified with the row-grave type of Ecker, which is believed to be Swabian and Alemannic. The only pure descendants of this race are the North Germans and the Swedes. From the statements of classical writers we may believe that the ancient Germans and Anglo-Saxons, like the existing Swedes, were blue-eyed, white-skinned, with abundant curly fair hair, flaxen or golden, and ample beard. This Scandinavian or North-German type is maintained by Penka and other German writers to represent the primitive Aryans, who conquered the other European races and imposed on them their own Aryan speech.

(2.) We have a second type, also dolicho-cephalic, called the Silurian type by

[1] Published *in extenso* in 'The Origin of the Aryans,' in vol. iii. of the *Contemporary Science Series.*

Professor Rolleston, which is found in the long barrows of England, and is represented by the skeletons in the Genista cave at Gibraltar and by those in the Caverne de l'Homme Mort in the Department of the Lozère, which have been so well described by Broca. This is called the Cro-Magnon type by De Quatrefages, and the Berber or Iberian type by other writers. The normal stature was short, averaging 5 feet 4 inches; 6 inches less than that of the other dolicho-cephalic race. The cephalic index is between 71 and 74. This race was orthognathous, and swarthy, with dark curly hair, oval face, and feeble muscular development. It is now represented by the Welsh of Denbighshire, by the Irish of Kerry and Galway, by some of the Scotch clans, by the Spanish Basques, the Corsicans, the Sicilians, the Berbers, and the Guanches of the Canary Islands.

(3.) We have a tall northern brachy-cephalic race, represented in the round barrows of the bronze age in England, in the tumuli of Denmark and some caves of Belgium. The average stature was 5 feet 8½ inches, the mean cephalic index was 81. It was macrognathous—with projecting teeth and powerful jaws, a square powerful chin, and a face quadrangular rather than oval. It is almost certain that the hair was light, either red or reddish-yellow. This race is the Cimbric race of Rolleston, the Kymry of Broca, the Sion type of Rütimeyer, the Turanian race of Dr. Thurnam, and the 'race Mongoloide' of Prüner-Bey. It was, in all probability, the race which introduced Celtic speech into England, and is now represented by the tall, yellow, freckled Irish, by some Highlanders, by the Danes, and most of the Slaves, by the Esthonians, and by many Finno-Ugric tribes.

(4.) The fourth prehistoric race was also brachy-cephalic, but short in stature. It never penetrated to England, but is represented in the sepulchral caves of the Lesse in Belgium. The stature was from 5 feet to 5 feet 3 inches; the mean cephalic index was 84; it was orthognathous and acro-cephalic. It is the Furfooz or Grenelle type of De Quatrefages, the Celtic type of Broca, the 'type Lapponoide' of Prüner-Bey, the Disentis type of Rütimeyer, and the Ligurian type of other writers. It is now represented by the short dark population of Central France, more especially by the Auvergnats, the Savoyards, and the French Basques. It is found in the Rhætian Alps and among the Lapps. The hair is black and straight and the eyes are dark.

These four types and no others appear to have occupied Europe in the neolithic period.

It is difficult to find for them unexceptionable names, but we may for convenience call the first the Scandinavian type, the second the Silurian type, the third the Slavic type, the fourth the Auvergnat type.

They are unmistakably distinct. There are two dolicho-cephalic types, one tall and fair, the other short and dark. There are also two brachy-cephalic types, one tall and red, and the other short and swarthy.

As from linguistic considerations it would appear certain that the undivided Aryans were unacquainted with metal, we must suppose that those who first used Aryan speech in Europe must belong to one of these four types, and that the other three types have been Aryanised by them—that is, that they are Aryans by language only, and not by race.

We have now to determine which of these four races was probably the original Aryan race.

We may begin by excluding the second or Silurian race. This race is to be identified with the Berbers and the Guanches, whose language belongs to the Hamitic family of speech.

We may also exclude the fourth or Auvergnat type, since their language seems to be represented by the Basque. The French Basques belong to this type, and the Spanish Basques to the Silurian; and De Quatrefages has shown that in the early neolithic period the Silurian race, which buried in caves, was driven back, conquered, and incorporated by the Auvergnat race, which buried in dolmens. North of the Pyrenees the Auvergnat race retained its language, south of the Pyrenees it imposed its language on the Silurian race, while in Central France it was conquered by the advancing Celts, whose language it adopted.

We have left only two neolithic types, one of which must be the ancestral Aryan

race. These two are the tall, fair, dolicho-cephalic Scandinavian race of the kitchen middens, and the tall, red brachy-cephalic race of the round barrows. In determining which of these is to be considered as the ancestral Aryan race, the following arguments have to be considered.

(1.) At the close of the neolithic age, or the beginning of the bronze age, the brachy-cephalic people invaded Britain. They must be identified with the Celts, and spoke an Aryan language. If at this time they were in possession of metal their civilisation was higher than that of the undivided Aryans, but they were the same race which in neolithic times occupied Belgium and Denmark, and were in the pastoral stage of civilisation of the undivided Aryans.

(2.) The Scandinavian race must be identified with the people of the Danish kitchen middens, who were ignorant of metals and the rudest agriculture, and whose only domesticated animal was the dog; whereas the primitive Aryans can be shown, on linguistic grounds, to have been a pastoral people, who had domesticated the ox and probably also the sheep and the goat, and who were acquainted with cereals of some kind.

(3.) Anthropologically this ancient Celto-Slavic race cannot be distinguished from the Ugric tribes of Eastern Russia, who are brachy-cephalic, and mostly with light or reddish hair. Now the Aryan speech exhibits so much agreement in its fundamental grammatical structure with the Finno-Ugric language that it can only be explained as having been evolved out of a language of this class.

(4.) The primitive Aryans must have either been by race Scandinavians or Slavo-Celts, and one must have imposed Aryan speech on the other. At the beginning of the historic period the Celts occupied the valley of the Danube, and the Teutons the coasts of the Baltic. They were in contact along the Erzgebirge—the central mountain chain of Germany. When two races are in contact, that which possesses the higher grade of culture usually succeeds in imposing its language on the less cultivated race. Now Dr. Schrader has shown that the early Teutonic culture-words are largely loan-words from the Celtic—especially the political, religious, and metallurgic terms. At some very early prehistoric period it would appear that the Celts who occupied Southern Germany dominated and civilised the ruder Teutonic tribes of Northern Germany. The Celts seem to have been in a higher stage of culture than the Germans, and therefore it is more probable that the Celtic race Aryanised the Teutonic race than that the Teutonic race Aryanised the Celtic race.

If, with De Quatrefages, we venture to trace back the neolithic races to palæolithic times, a further generalisation may perhaps be ventured on, and the four neolithic races may possibly be reduced to two. Stature and complexion are more variable than the shape of the head and of the orbits of the eyes. The two brachy-cephalic races, the Lapponoid and the Mongoloid, may have had a single origin, and be referred to the Grenelle race, whose stature was nearly that of the Magyars, while the dolicho-cephalic races may also be referred to a single type—that of the Neanderthal or the Cro-Magnon skull. The first, with its high cephalic and orbital indices, is essentially Asiatic, and may be affiliated to the yellow race; while the second, without its low cephalic and orbital indices, is essentially African, and may be affiliated to the black race. Two hypotheses are possible—either the human race originated in Europe, bifurcating into the African and Asiatic races; or we may suppose the white or European race to have originated from the union of the yellow race of Asia and the black race of Africa.

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5. *The Ethnological Significance of the Beech.*[1] *By* Canon Isaac Taylor, *Litt.D., LL.D.*

While the Latin *fagus* and the Gothic *boka* denote the beech, the word has come to mean the oak in Greek. Professor Max Müller, noting the fact that in prehistoric times the beech-forests of Denmark were preceded by oaks, conjectured

[1] Published *in extenso* in *Knowledge*, November 1889.

that the word originally denoted the oak, and was transferred to the beech when the change of vegetation took place. But this explanation must be rejected, since Helbig has proved that the Latin race entered Italy in the stone age, while the change of vegetation in Denmark only took place in the bronze age. The word *fagus*, therefore, must have denoted the beech in Latin at a period prior to the change of vegetation to which Professor Max Müller attributes the alteration in the meaning of the word.

Geiger and Fick maintain that the change in the meaning of the word was due to the Greeks having migrated from a land of beeches to a land of oaks, and that they transferred the name of the one tree to the other, just as the New Englanders transferred the names of the robin, the maple, and the hemlock to wholly different species. The line between the ilex, or evergreen oak, which is the characteristic tree of Southern Greece, and the beech, which is not found south of Macedonia and Epirus, passes near Dodona, round which are clustered the oldest sacred traditions of the Greeks, and where they made their earliest settlement on their progress towards the south.

It would, therefore, seem probable that the word *fagus* originally denoted the beech and not the oak, also that the Greeks entered Hellas from the north-west.

The range of the beech is limited. It is a lover of chalk soils, and does not grow east of a line drawn from Königsberg to the Crimea. West of this line we must therefore put the cradle of the Latin, Greek, Celtic, and Teutonic peoples, as they had the same name for the tree prior to their linguistic separation. The Lithuanian and Slavonic tongues must have originated east of this line, as their name for the beech is a loan-word from the German. But in earlier times the northern range of the beech was more restricted, and it is believed that in the neolithic age it had not reached Britain, Holland, Denmark, or the Baltic coast. The early home of the beech seems to have been limited to France, Central and Southern Germany, Northern Greece, and Northern Italy. If, as has been contended, the cradle of the European Aryans was in Central Asia, where the beech is unknown, it is difficult to explain how the ancestors of Celts, Latins, Greeks, and Teutons, migrating, as Pictet contends, at different times and by separate routes to lands where the beech abounds, should have called it by the same name, modified in each case by the fundamental phonetic laws of the various languages.

It is easier to believe that the cradle of the Aryans was, so to speak, astride of the beech line, the ancestors of Celts, Latins, Greeks, and Germans living to the west of it, and those of the Lithuanians and Slaves further to the east.

Further, since the beech had not extended so far north as Denmark in the neolithic age, and as the pro-ethnic Aryans seem to have been acquainted with this tree, it is more probable that the primitive Aryan race is to be identified with the brachy-cephalic Celto-Italic people of Central Europe, than with the dolicho-cephalic people of the kitchen middens.

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6. *The Right of Property in Trees on another's Land, as an origin of Rights of Property.* *By* HYDE CLARKE.

The author stated that his attention was first called to the subject, as a land-judge or commissioner in Asia Minor, in 1862, in granting compensation for olive-trees belonging to one or more individuals on the fields of others, and for honey-trees or hoards of wild honey in State or Communal forests. In 1888 the Rev. Dr. Codrington read a paper at the British Association, and afterwards at the Anthropological Institute, which gave information as to the existence of a like system in Melanesia. The author thereupon proceeded to make further inquiries, and found evidence as to its existence in Borneo, with regard to Tapang or honey-trees, and in Chota Nagpore (and probably elsewhere in India) as to the Mhowa, a tree furnishing food, spirit, oil, &c. In China a lessee has the right to bamboo, &c., grown by him. The practice in the Turkish Empire he found extended into the European provinces, as applied to plum-trees in Bosnia. In Ireland it was recognised in the Brehon

Laws as an individual property separate from tribal property. Generally speaking, the right does not exist in Europe, as all rights are centred in the owner of the soil. It is probable that the personal right of the first discoverer of honey and similar trees, a right defined by Sir H. S. Maine as dependent on discovery, is to be regarded as the origin of an individual right of property rather than any right in land, which is of no value in a primitive community. Even cultivable land belonged to the community, and was distributed by lot yearly, of which there are modern examples.

7. *Report of the Committee appointed to investigate the Habits and Customs and Physical Characteristics of the Nomad Tribes of Asia Minor, and to excavate on sites of ancient occupation.*—See Reports, p. 176.

SATURDAY, SEPTEMBER 14.

The Section did not meet.

MONDAY, SEPTEMBER 16.

The following Reports and Papers were read:—

1. *Report of the Committee for editing a new Edition of 'Anthropological Notes and Queries.'*—See Reports, p. 186.

2. *Report of the Committee for calculating the Anthropological Measurements taken at Bath.*—See Reports, p. 423.

3. *Exhibition of a new Anthropometric Instrument, specially designed for the use of Travellers. By* Dr. J. G. GARSON.

4. *An Instrument for measuring Reaction Time.*
By FRANCIS GALTON, *F.R.S.*

The principle of the instrument exhibited, and the scale of its graduations, were described a few months since ('Journ. Anthrop. Inst.,' xix. 1, p. 28), but the details of its construction have been greatly improved. It measures in a very simple manner, the interval that elapses between (1) making a Signal either by Sight or by Sound, and (2) the Response given to it by the person who is experimented on. It consist of a half-second's pendulum held by a detent at an inclination of 18° to the vertical; when the detent is depressed, the pendulum begins to swing. The depression of the detent may be effected silently: then levers, an arrangement connected with it, cause a disc of paper to disappear noiselessly, which gives a Sight Signal. Or else a hammer is allowed to strike the detent aside, which gives a Sound Signal. The Response is made by pressing a key, that causes an elastic thread to be suddenly nipped and held fast. This thread is attached above and below to the rod of the pendulum, and parallel to it. Owing to the very small inertia of the thread it can be suddenly checked while in full swing; and owing to its elasticity the sudden check communicates no jar to the pendulum. The position of the nipped thread indicates that of the pendulum at the moment when

it was nipped. It is read on a properly graduated scale that is disposed as a chord to the arc of oscillation. The graduation at the point where the thread is nipped, shows the number of hundredths of a second that had elapsed between the Signal and the Response. The instrument was made for the author by Mr. Groves, 89 Bolsover Street, London, W.

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5. *The Smithsonian Institution in the United States of America, and its work relating to Anthropology.* *By* Dr. THOMAS WILSON.

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6. *The Study of Ethnology in India.* *By* H. H. RISLEY.

The paper commenced by explaining the special conditions, social and administrative, which make India a readily accessible and peculiarly instructive field for ethnological and, more especially, for anthropological researches. It went on to describe the measures adopted during the last four years under the sanction of the Government of Bengal for a general ethnographic survey of the population (70,000,000) of that province, and for a special anthropometric inquiry into the physical characteristics of the people of Bengal, the North-Western Provinces, Oudh, and the Panjáb. In the course of the anthropometric survey measurements were taken, on the system prescribed by Dr. Paul Topinard, of Paris, and approved by Professor Flower, President of the British Association, of 6,000 persons, representing eighty-nine different tribes and castes.

Some of the main conclusions which these inquiries indicate were then stated. It was shown that the population of Northern India comprised three distinct types, viz.:—

I. A leptorhine dolicho-cephalic type of tall stature, fair complexion, and high facial angle, apparently corresponding in all points except hair and complexion with the Aryan type as defined by Herr Karl Penka of Vienna.

II. A platyrhine dolicho-cephalic type of low stature, black or very dark complexion, and low facial angle. The wider racial affinities of this type are uncertain, and it is tentatively and conjecturally described as Australioid.

III. A mesorhine, platyopic, brachycephalic type of low stature, yellowish complexion, and low facial angle, described, in virtue of its low nasomalar index, as Mongoloid.

The types thus worked out by anthropometric methods are shown to correspond with certain ethnographic groupings independently ascertained. Thus the leptorhine group have exogamous subdivisions of the eponymous type; the platyrhine group have their exogamy on the totem; while the brachycephalic group make use of a system of personal nicknames for this purpose. In the Aryan and Australioid types the social status of each caste or tribe is found to vary inversely as its nasal index; tribes with the highest index having the lowest social rank, and *vice versâ*. In the brachycephalic group social status appears to vary with the cephalic index.

An attempt was made to deduce from these data a theory of the probable origin of caste, and also to account for the custom of exogamy by the operation of the law of natural selection.

The concluding part of the paper discussed the practical bearing of ethnology upon certain administrative and social questions in India, such as famine relief; the management of the Excise revenue; the relations of landlord and tenant; the prohibition of widow marriage; the continual extension and perversion of the disastrous custom of infant marriage; and, lastly, upon the remarkable movement known as the National Congress, the main feature of which was the demand by natives who have received an English education for the extension of representative institutions to India.

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7. *On some former Customs and Beliefs of the Torres Straits Islanders.* *By* Professor A. C. HADDON, *M.A.*, *M.R.I.A.*

The natives of Torres Straits are divided into two distinct tribes—the Eastern tribe, which inhabits Uga, Erub, and the Murray Islands; and the Western tribe, which occupies all the remaining islands. There are four subdivisions of the latter tribe, the members of each of which inhabit certain groups of islands.

Independently of the above-mentioned subdivisions the islanders were divided into clans, each clan having some animal for its totem, such as the dugong, turtle, dog, cassowary, snake, shark, &c. With the exception of the first two no man was allowed to kill the totem of his own clan. If he did his fellow-clansmen would probably kill him. On a dugong expedition no dugong man might keep the first dugong he captured, but he might partake of all the rest. The same applied to the turtle clan. The women used to have a representation of their totem cut on the small of the back.

In the Western tribe the lads on entering into manhood underwent a month's isolation in the bush, during which time they were covered over with a mat, were coated with charcoal, and were not allowed, on pain of death, to see any woman or even their own fathers. Neither were they allowed to talk or play. A relative attended them during that period and taught them the customs and system of morality of the tribe. This was followed by a grand feast, when the lad was presented to his relations gaily ornamented, and thenceforth he took standing as a man. In the Eastern tribe two elaborate ceremonies attended the initiation of the lads, but the discipline does not appear to have been so severe as in the other tribe.

It was the custom in the Western tribe for the women to ask the men in marriage. This was attended with certain recognised formalities. The usual money value for a wife was a canoe, or a dugong harpoon, or a shell armlet. On the other hand, in the Eastern tribe the men proposed to the women, and the women had to undergo a period of partial seclusion previous to marriage. The eating of food together was a feature in marriage.

The funeral customs of the Western tribe appear to have been elaborate. The first operations culminated in the preparation and decoration of the skull of the deceased. The second stage was characterised by handing over the skull to the nearest relatives, the occasion being celebrated by remarkable dances, in which it was a matter of great importance that the women should not recognise the disguised dancers. There were three persons engaged in the main dance, the central one being a man dressed up as a woman. The spirit of the deceased was supposed to go to a mythical island, Kibuka, in the west. The Eastern people made their dead into desiccated mummies, which they kept in their houses. Funeral dances were also held. The departed spirits went to Boigu, an island in the west.

Belief in sorcery was universal, and all sickness and death were attributed to the charms of the medicine-man. There were also rain and wind-makers.

There was considerable intra-insular trade, and also between New Guinea (Daudai) and the islands. Canoes were frequently bought on the three-year-hire system.

Most of the stars are grouped into constellations, about many of which myths have sprung up. Legends are also attached to numerous prominent rocks and stones. There are several stories about culture-heroes. All of these narratives date from before intercourse with white men.

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8. *Anthropological Notes collected at Mowat, Daudai, New Guinea.* *By* EDWARD BEARDMORE.

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9. *The British Race in Australia.* *By* Dr. MACLAURIN.

The author did not think there was any distinct type of configuration in the Australian-born inhabitant which would enable them to distinguish him from the ordinary Englishman or Scotchman. The muscular vigour of the British Austra-

lian race could be estimated by the readiness with which it entered into athletic exercises, and the result of this they had all seen in the number of sculling champions and cricket teams which had recently visited this country. Australia still depended upon the mother country for the most responsible posts to be filled, but the apparent barrenness of the Australian intellect did not point to natural incapacity. Regarding the longevity of the individual, statistics were rather interfered with by the disturbing effect of immigration, yet the return showed that the number of old people living there had been increasing. On the subject of the vitality of the British race in New South Wales, the writer pointed out that between the years 1871 and 1881 the population of New South Wales was increased by 247,487, being at the rate of 49·1 per cent. on the population existing in 1871, or at the rate of 4·81 per cent. per annum. Practically, therefore, the population was increasing through the excess of births over deaths, which he thought showed that the vitality of the race had not been diminished by transplantation to Australia. Giving his opinion, after many years' residence in Australia, the writer said that the white race there showed no signs of deterioration either physically or mentally, and while a sufficiently long time had not yet elapsed to enable them to tell what manner of men Australians will be, yet they could safely conjecture that they would prove themselves worthy of their ancestors.

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10. *Observations on the Natural Colour of the Skin in certain Oriental Races. By* Dr. BEDDOE, *F.R.S., President Anthr. Inst.*

The author made numerous observations of this kind in the course of a voyage round the world. In most cases he found the colour of the clothed and protected body much lighter than is generally supposed. The capacity to tan, or become darker by exposure, varies much; thus, the Melanesians are naturally lighter than the Australians, but they burn much blacker.

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11. *The Normal Temperature of Soudanese, Negroes, and Europeans in Tropical Africa. By* R. W. FELKIN, *M.D., F.R.S.E.*

Observations made in 1878–81 apparently showed that the normal temperature of Soudanese, negroes, and Europeans varied from the usually accepted normal temperature of 98°·6 F.

After detailing the observations the writer stated his conclusions as follows. The normal temperature of Europeans who had resided in tropical Africa between Khartoum and the equator for over four years was 99°·1 F.; the normal temperature of Europeans in the same region, none of whom had been more than two years in Africa, 99°·5 F.; the normal temperature of Soudanese (Arabs), 99° F.; that of negroes living between the equator and 10° N. lat., and on the east coast of tropical Africa, average of 600 observations, 97°·8 F. NOTE.—All the observations were made two hours after eating, the individual at rest in the shade, with the thermometer in the axilla.

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12. *The Differences of Sensibility between Europeans and Negroes, and the Effect of Education in increasing the Sensibility of Negroes.*[1] *By* R. W. FELKIN, *M.D., F.R.S.E.*

It is very generally supposed that negroes feel pain to a less degree than Europeans. In investigating this subject the writer tested the power of sensation as shown by the capacity for appreciating the two points of a compass in various regions of the body, comparing the results with the normal tactile sensation of Europeans as given by Landois and Stirling.

Tactile sensation was tested in twenty-six parts of the body on 150 negroes and on 30 Soudanese (Arabs). An example will best summarise the results of the

[1] Published *in extenso* in the *Journal of the Anthropological Institute.*

observations. It is stated that the minimum distance at which the two points of a pair of compasses can be distinguished at the tip of the tongue is, on an average, 1·1 mm. in Europeans. It was found to be 3 mm. in negroes, 2·6 mm. in Soudanese. After two negro boys had been educated for four years in England it was found that their tactile sensation had become more acute, and they could then distinguish the points of a pair of compasses at 2 mm. Observations on the various regions of the body bore approximately the ratio indicated above.

TUESDAY, SEPTEMBER 17.

The following Papers and Reports were read:—

1. *The Esquimaux. By* Dr. FRIDTJOF NANSEN.

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2. *Northumberland in Prehistoric Times. By the* Rev. G. ROME HALL, *F.S.A.*

Prehistoric archæology is an important branch of anthropology, the science of man as found in all places and all times. It is the connecting link between geology and history. As respects the prehistoric periods in this county a brief notice alone is possible on this occasion. The old Saxon Northumbria is not in question—that is, the land north of the Humber far-reaching to the Firth of Forth—but the comparatively modern Northumberland, greatly lessened in its geographical area. If the present paper had regard to the former, this review of the time preceding the Roman Conquest would have to be begun with the evidence of the existence of *Palæolithic*, or cave-men, contemporary with extinct animals, discovered in the Victoria and other caves near Settle, in Yorkshire. On the east coast of England, however, no trace of them has as yet been found farther north than Norfolk. We come, after an immense and unknown lapse of time, to the *Neolithic* period, when the earliest inhabitants of Northumberland, who were, so far as we can ascertain, cognate with the Basques and Lapps, crossed the Tyne in small family or tribal bands. Though probably never numerous, their polished weapons and implements have been frequently found. Many of these may belong to a later epoch, as the various periods overlapped. There is no evidence from barrow exploration of a dolicho-cephalic race nearer than the Yorkshire Wolds. 'Long heads' reappear afterwards, but very rarely; perhaps through intermarriage with their conquerors. These bring us to the *Bronze* period, of which relics of nearly all known varieties, found between the Tyne and Tweed, may be inspected in our public and private collections, especially in that of the Rev. William Greenwell, F.S.A., such as swords, spear and javelin heads, celts, rings, pins, &c., the smallest implements being placed with the dead, the large being too valuable to the living to be thus disposed of in burial-mounds. Considerable hoards of bronze articles have been found near Alnwick, Rothbury, and Wallington. Gold was now in use, as it may also have been in Neolithic times, as beads of that always precious metal were discovered in a barrow at Four Laws, or Chesterhope, together with a thin bar of bronze. Near Bellingham, in North Tynedale, a gold armlet was found. Burial by inhumation was customary in the later Stone age, and cremation followed. In Ancient British times in this county Mr. Greenwell has ascertained, judging from his own explorations, that the proportion of cremated to inhumed bodies is nearly as two to one; but both modes of burial are frequent in the same 'family' barrow, as at Warkshaugh and Pitland Hills, near Birtley. Interments were sometimes in split-oak coffins, found at Featherstone; but usually in stone-lined graves, the body being doubled up as in the posture of sleep, sometimes with an urn, a 'food-vessel,' placed near the head. Cinerary urns, containing ashes of cremation, very rarely with a small 'incense-cup,' are also often found in the burial mound. The British name

'kist' for a stone coffin is still used by Northumbrian cottagers for their wooden chests or boxes, which are about the same shape and size. The grave-slabs have often graven upon them archaic sculpturings of cup and rings—mysterious symbols first found at Doddington and Old Bewick in Northumberland, in rocks near Ancient British 'camps,' and since then observed on monoliths and other stone monuments from Argyllshire to Cornwall. Similar rock-markings in India Mr. Rivett-Carnac found associated with 'Mahadeo,' or Lingam worship.

The bronze-using people were probably Aryans, of the first wave of migration westwards, the Gadhelic branch of the Celtic stock. They were taller and fiercer-looking than the Neolithic people, having high cheekbones, and were a brachycephalic, or round-headed, race.

The succeeding Celtic migration were Brythons or Cymry, allied to the Welsh and Cornish, who drove the Goidels or Gadhaels westwards into the Isle of Man and Ireland, and northwards into the Highlands of Scotland. This success seems owing to their possession of weapons of iron. To this *Iron* period we owe the introduction of the greater part of the names of our mountains and hills, rivers and streams; as the Tyne, from *don* or *tan*, the water. This metal we all know is so perishable that it is no wonder few weapons or utensils of pre-Roman or any other age remain to us. Bronze was also in use during the same period, in which we still may be said to live, though ours is an age of steel rather than of iron.

When did Neolithic man first appear in this district? Far distant indeed the time must be, thousands of years since; and as to Palæolithic man, of the bone caves, his existence, outside our county, we cannot but trace back to tens of thousands of years. The bronze-using invaders may have landed about B.C. 1,000, and the Iron age in Northumberland may have begun about B.C. 500 or 400. We can only venture to make in this matter a reasonable conjecture. Agricola, about A.D. 80, introduced among our Ancient British ancestors a new civilisation, and taught them, *more Romano*, a higher and fuller life.

We know what manner of men these brave aborigines were, and how they lived, from their defensive hill-forts and valley-fastnesses, like Yevering Bell, Greaves Ash near Linhope (a triple town), Gunnar Peak Camp, and innumerable others. Sometimes they occupied pit-dwellings and huts, generally of circular form, outside the ramparted forts, but chiefly clustered within these strongholds, palisaded like Maori pahs. They were hunters of deer, wolf, bear, wild-boar, and other animals in the primeval forests, but had domestic cattle and sheep of a small breed. Deep in the silt of the rivers Tyne and Derwent, canoes for travel and fishing, hollowed out of oak trees, have been found. Spindle whorls denote some skill in weaving. They cultivated a little corn on terraced slopes—of which many fine examples exist, as at Birtley. They had great earthworks, perhaps for judicial assemblies, like the Gunnarton Money-Hill, and Elsdon and Wark, where Roman altars have been discovered, showing a later occupation. One stone circle, out of several destroyed in the county, remains at the Three Stone Burn, near Yevering Bell; the fine circle at Nunwick, described by Bishop Gibson, has long disappeared. A great monolith, or standing stone, may be seen near Swinburn Castle—others elsewhere. Northumberland is like Devonshire (but possessing no avenues of stones, or cromlechs), and is richer in its variety of prehistoric remains than Yorkshire, Durham, or Cumberland. The frequent barrow on the moor or by the river shows us their religious feeling and reverence for their beloved dead. Modern Northumbrians may perchance owe more than they think to the combination of racial characteristics resulting from the continuity of life proceeding from even prehistoric times down to the present day.

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3. *On Implements of Stag's Horn associated with Whales' Skeletons found in the Carse of Stirling. By* Professor Sir WILLIAM TURNER, *M.B., F.R.S.*

Those who are acquainted with the valley of the Forth know that the River Forth winds for many miles through an extensive plain, called the Carse of Stirling. This plain is a raised sea-beach, which reaches from 5 or 10 to 30 feet

above the present level of high water. Geologists regard this beach as a post-glacial accumulation of marine origin, for the shells which it contains are not Arctic but those of molluscs now extant in the seas of Scotland. In the subsoil of this raised beach the skeletons of large whales have from time to time been found, and as many as seven well authenticated specimens have been recorded. They were all got under almost similar conditions, imbedded in a blue silt which underlay a former peat moss, at a depth of usually three to five feet below the present surface of the ground, and at levels varying, it is said, from 5 feet to 25 feet above the present high-water mark. At the time when those whales were stranded the estuary of the Forth would have extended some eight or ten miles to the west of the site of the town of Stirling, and there must have been a sufficient depth of sea to permit, with a flowing tide, large whales to swim many miles further west than is now possible, with the risk, however, of becoming stranded as the tide receded. It has been customary to speak of these whales as Greenland whales; by which term, I presume, has been meant the right whale, *Balæna mysticetus*, which is an Arctic species. But the skeletons which I have examined did not belong to the genus Balæna, but to the genus Balænoptera, or the Finner whales, several species of which now frequent the British seas. I have identified one skeleton as that of *Balænoptera musculus*.

Associated with certain of these skeletons implements of stag's horn have been occasionally found. The first specimen on record was obtained in 1819, on the estate of Airthrey, close to the east gate of approach to Airthrey Castle. Mr. Robert Bald, who described the finding of this skeleton, stated that close by it two pieces of stag's horn were also got, through one of which a hole of about an inch in diameter appears to have been bored. In 1824 the skeleton of a large whale was exposed in digging a ditch on the estate of Blair-Drummond. Along with the skeleton was found a fragment of a stag's horn, said to be like to that got along with the Airthrey whale, and with a similar round hole bored through it. Mr. D. Milne Home, in his work on the Estuary of the Forth, states that Mr. Home Drummond had informed him that a small piece of wood was in the hole in the horn, which fitted it when found, though it has since considerably shrunk. Unfortunately no trace of any of these pieces of stag's horn can now be obtained. It can scarcely be questioned that the two horns with holes in them had been fashioned into implements by human hands, but neither Mr. Bald nor Mr. Home Drummond gives the shape of the pieces of horn, nor states the probable use to which they had been applied. Several writers who have subsequently referred to these specimens have, however, described them as lances or harpoons; but the brief statements about them by their discoverers scarcely justify this inference, for in the fitting of a handle into either of such weapons a hole would not be bored through the weapon but into one end of it.

It is with peculiar satisfaction, therefore, that I have had an opportunity of examining a third specimen of a stag's horn made into an implement and associated with a whale's skeleton. In 1877 the skull and other bones of a Balænoptera were exposed in the course of drainage operations on the estate of Meiklewood, a few miles west of Stirling. Resting upon the front of the skull, and lying vertically in the blue silt, was an implement made of the horn of a red-deer, which possessed the following characters:—It was 11 inches long and $6\frac{1}{2}$ inches in its greatest girth. It consisted of a portion of the beam of the antler immediately above the frontal burr and brow antler, and included that part of the beam from which the tine second in order from the frontal burr had sprung. This tine had been broken off, and a hole had been bored, at that spot completely through the thickness of the beam, 4 inches from one end and 7 inches from the other. The greatest circumference of the implement was at the part through which the hole was bored, and here it was slightly curved. The aperture where it opened on the convexity from which the tine had sprung was oval and elongated in the long axis of the beam, its dimensions being $1\frac{1}{4}$ inch by $\frac{3}{4}$ inch; on the opposite aspect the aperture was almost circular and $\frac{3}{4}$ inch in diameter. The shorter segment of the antler was truncated, and shaped so that it could have been used as a hammer. The opposite end was bevelled and smooth and polished to a

sharpish edge, like that of an axe or chisel. In the process of forming this edge one side of the antler had been rubbed down much more than the other, so that the edge was formed by the hard solid part of the antler. The smooth shining surface of this edge contrasted with the rough tuberculated appearance of the rest of the antler. A piece of wood, $1\frac{3}{4}$ inch long, occupied the hole in the antler. Though much shrunk, so as not to fill it, it was obviously the remains of a handle with which the implement had been provided. The circular shape of the hole on one aspect and its oval form on the other lead one to infer that the handle had been a circular stick, secured in the hole by wedges of wood, after the manner in which the handle of an axe is now fitted. From the hole not being midway between the two ends, the implement was not evenly balanced, and the bevelled end was longer than the hammer-shaped extremity. The selection of the end of the antler furthest from the frontal burr for the formation of the bevelled edge enabled the maker to obtain a denser part of the horn for the cutting edge. When used with a handle the bevelled end could be employed as an axe, and without the handle it could be used as a chisel. I have little doubt that the implements found along with the Airthrey and Blair-Drummond whales corresponded in shape to that which I have just described. Implements made of the antlers of the red-deer are well known to archæologists, and drawings and descriptions of several varieties may be found in various publications. As a rule they seem to have been fashioned into hammers or sharp-pointed implements. The particular pattern found with these ancient whales is somewhat unusual. In the Royal Museum at Brussels, however, are some specimens from the Belgian bone caves which closely resemble in shape that which I have described. I may refer especially to those found in the Caverne de Montaigle, which were perforated with a hole for a handle, had one end truncated, and the other bevelled to a chisel-like edge.

The discovery of these horn implements proves that, when the fertile land now forming the Carse of Stirling was submerged below the sea level, the surrounding high lands were inhabited by a hardy Caledonian race, who manufactured from the antlers of the red-deer useful tools and weapons. I have already stated that there is nothing in the form of these implements to lead one to suppose that they could be used in the chase of the whale as lances or harpoons. It is probable that the whales by the side of which they were found had been stranded during the ebb of the tide, and that the people had descended from the adjacent heights, and, with the aid of their chisels of horn, had spoiled the carcase of its load of flesh and blubber. In support of this view I may state that the three skeletons along with which the implements were found were lying in proximity to the edge of the Carse land, where it approached the adjacent high ground. It is expressly stated by Mr. Blackadder that the Blair-Drummond whale was found within 400 yards of the margin of the Carse clay. The Airthrey whale was exposed near the high ground of the Abbot's Craig; whilst the Meiklewood whale was lying at no great distance from the foot of the Gargunnock hills.

We cannot fix a precise date when the men whose implements we have been considering lived in Scotland. It was of course long before the Roman occupation of Britain, and preceded the beginning of the present adjustment of land and sea on our coasts. It is doubtless to be referred to the period termed the Neolithic, the termination of which, according to the estimates of M. Morlot and other geologists, could not have been less than from 5,000 to 7,000 years ago.

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4. *The Origin of Human Faculty.*[1] *By* Professor G. J. Romanes, *F.R.S.*

The author said that as the body of man was held to have been evolved, so there was an *à priori* probability that his mind had also been evolved from a rude condition, and that probability was confirmed by the facts of comparative psychology. Animal and human intelligence showed correlative progress in development, especially in the emotions, except of course in morals and religion. Such an *à*

[1] Published *in extenso* in *Brain*, Oct. 1889.

priori presumption could only be met by adducing some very cogent reasons of an *à posteriori* kind, showing that there was some super-added element in human intelligence. Only three such elements had been suggested—namely, conceptional thought, morals, and religion, the two latter, however, being dependent upon the former. The conclusion at which Professor Romanes arrived was that, although it must be admitted that the distinction of a true self-consciousness from lower grades of mental development was no doubt a very great and important matter, still it was not so great and so important in comparison with what this development was afterwards destined to become as to make us feel that it constituted any distinction *sui generis* between man and the brute. Even when self-consciousness arose, and it became fairly well developed, the powers of the human mind were still in the most infantile condition.

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5. *On the relations between Brain-Functions and Human Character. By* Bernard Hollander.

The failure of a scientific basis to human character and a correct analysis of the fundamental human dispositions must be attributed to the want of knowledge of the functions of the brain and nervous-system, and to the preference with which men have hitherto followed metaphysical speculations on the human mind in comparison to physical research. The study of comparative anatomy, of craniology, of the evolution of the intellect, of heredity, of mind in animals, of the growth of intelligence in children, and the perversion of the faculties in the insane, and other studies which help us to understand human nature, are of comparatively recent origin, while the most important of all—that is, brain-physiology—is still most obscure. It is only recently that the plurality of functions of the brain has been demonstrated scientifically; and though a number of English and foreign investigators have succeeded in localising centres for motion and sensation, we are still in need of a method which will enable us to demonstrate centres of ideation or thought. A number of experiments have been made on the cortex of animals, with the result of defining distinct regions for motion and sensation, either by exciting definite portions of brain, and watching the movements that occur, or by destructive lesions and observation of the loss of movements; and though the results in themselves were not, hitherto, considered to be of direct value to the student of mental science, they demonstrate, as will be shown, the physical parallel of certain emotions, and confirm actual localisations made empirically by earlier investigators, whose work, however, has been long ago rejected on account of the insufficiency of their method.

This communication is intended to be a collection of facts relating to the subject of brain-functions, in their subjective and objective aspects, with the view of showing the possibility of a 'scientific' phrenology and the necessity of re-examining the empirical observations made by Dr. Joseph Francis Gall, bearing in mind the defects of his system and the overstrained pretensions of his followers.

(*a.*) Experimental physiologists are agreed that the most intense centres for movements of the 'facial' muscles are in a portion of brain extending from the gyrus centralis anterior to the latter end of the middle frontal convolution. This localisation is confirmed by pathologists, and all observers are struck by the frequency with which disease of the 'facial' nerve occurs, together with loss of articulation of speech (*see* Professor Dr. Sigmund Exner, 'Localisationen der Functionen der Grosshirnrinde des Menschen,' Wien, 1881). This brain-area corresponds with that in which Gall located his 'organ of mimicry,' which he supposed to be the physical condition for a talent for the imitation of gestures of other people, and which he noted to be often accompanied by a talent for imitating the voice of others, thus constituting the necessary fundamental dispositions to the art of 'acting.'

(*b.*) Professor Ferrier's localisation of the 'gustatory centre' at the tip of the lower temporal convolution, the centre which sometimes gives rise to ravenous appetite, or sitophobia, exemplified in certain forms of insanity, is exactly the same as that of 'gustativeness' or 'alimentiveness' as made by the early phrenologists,

and which they supposed to incite us to the sensual enjoyment of the palate, and the activity of which is independent of hunger and thirst.

(*c.*) Professor Ferrier ('Functions of the Brain,' p. 463, &c.) considers intellectual attention to be essentially ideal vision, and says that when we are concentrating our attention the ideal object is held in the field of clear vision by appropriate ocular movements, which react back on the centres of vision and keep the ideal object in the field of clear consciousness, and through this recall its various sensory and motor associations. He comes to the conclusion that the centre of vision is the centre for concentration of attention. Professor Ferrier supposed the angular gyrus to be the centre of vision, but it is now shown by Professor Schäfer ('Royal Society Proceedings,' December 22, 1887) and by many foreign observers to be in the 'first occipital convolution,' the same area in which George Combe located the same power, naming it 'concentrativeness,' which he supposed to enable one to fix one's attention for a long time on one object.

(*d.*) The area, a portion of the ascending frontal convolution, in which Professor Ferrier locates the centre for movements of the elevator muscles, the same which are called into action in joyful emotions, and enable us to elevate the cheeks and angles of the mouth as expressed in smiling, is the same in which George Combe located the organ of cheerfulness—badly termed 'hope' on account of the grandiose delusions which are created when the organ is in an excited state. Sir James Crichton Browne and others have noted that in the disease known as general paralysis of the insane there is almost invariably optimism, insane joyousness, delusions as to wealth and grandeur, while the earliest physical symptom is trembling at the corners of the mouth and at the outer corners of the eyes; and Dr. Voisin explains this condition ('Traité de la Paralysie Générale des Aliénés,' 1879) by supposing the existence of a centre of exaltation.

(*e.*) Mr. Herbert Spencer, the eminent philosopher, who wrote in his younger days some clever articles on phrenology (*see* 'Zoist,' vols. 1 and 2), in which he expressed his belief in Gall's system, and showed himself an acute observer, localises in the latter halves of the lower frontal convolutions, in the area which was thought by Gall to be connected with 'visions,' the faculty of 'reviviscence.' His theory is that the proposed faculty is 'the chief agent for the revivification of ideas, the chief agent of imagination, and that it affords a tangible explanation of mental illusions.' He quotes many examples of men of powerful imagination like Dante, Tasso, Swedenborg, and others who have been subject to mental illusions, and asks his critics to examine the likenesses of poets to see the predominance of the corresponding skull-area. Modern pathologists thought at one time that spectral appearances were caused by disturbed brain-centres of vision; but an examination of the cortex of the insane has shown that the supposed visual brain-area is hardly ever affected, while the posterior zone of the frontal convolutions always shows adhesion, decortication, and wasting. Further evidence is deducible from the fact that physiological experiments confirm Mr. Herbert Spencer's theory, for, as Professor Ferrier explains, the movements caused by excitation of this area are essential to the revivification of ideas.

(*f.*) Lesion of the angular gyrus is shown by Munk ('Ueber die Functionen der Grosshirnrinde,' Berlin, 1881) and others to cause so-called 'psychical blindness' (Seelenblindheit), and numerous experiments demonstrate the 'non-perception of danger' in those animals in which this gyrus has been destroyed. Adjoining it, *i.e.* at the extremity of the ascending parietal convolution, Professor Ferrier locates the centre for movements of the 'platysma myoides muscle,' on the importance of which, in the expression of fear, both Darwin and Sir Charles Bell dwell, while Duchenne calls it the muscle of fright. The whole area corresponds with the area in which Gall located his organ of 'apprehension,' afterwards called 'cautiousness,' which he supposed to be excited when we are in a state of anxiety or fear, and which region he found enormously developed in persons known to take alarm easily and who could be easily terrified.

(*g.*) Darwin's and Herbert Spencer's description of the physical expression of the 'irascible' emotion in animals, as, for instance, when about to attack an antagonist, is a drawing back of the ears, gnashing of the teeth, and growling;

while Professor Ferrier observed that the excitation of the superior temporo-sphenoidal convolution in monkeys and the corresponding convolution in dogs caused retraction of the ear, accompanied occasionally by a sudden spring or bound forward; and in cats it caused opening of the mouth, associated with vocalisation and other signs of emotional expression, such as spitting and lashing of the tail as if in rage. [Ferrier's localisation of the auditory centre in this same convolution has been rejected by foreign investigators, and by Professor Schäfer in this country ('Royal Society Proceedings,' December 22, 1887).] This area is no other than that which Gall found so prominently developed in all carnivorous animals and in murderers, and which he supposed to be the physical condition of the destructive propensity or irascible emotion.

The examination has not been completed, for, even limited as it is, it will excite much criticism. Little has been said of the analysis of human character, and no mention has been made of the arguments in favour of the plurality of functions of the brain, as, for instance, the necessity of there being special ideational centres; otherwise it would be impossible to explain the hereditary transmission of peculiarities of character and mental characteristics from parent to child, for the subject is a wide one and cannot possibly be treated in one communication. I hope to have shown, however, 'That the founders of what we are accustomed to consider as the antiquated system of phrenology, though unable, in what was the state of knowledge at that time, to demonstrate their conclusions, must have been extremely shrewd and careful observers of all the facts which lay within their reach, and that the theories which they based upon these observations are well worth a careful re-examination in the light of modern science.'

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6. *On a new Method of illustrating the Topography of the Brain in relation to the External Surface of the Head. By* Professor FRASER, *M.B.*

The author treated first of the manner by which he prepared his heads, so that they should be in a perfect condition through and through; then of the large photographic apparatus which he used for reproducing serial dissections of the head and neck, life-size. Also of the manner in which, by combining several views direct from nature on one plate, he had been able to make the head practically transparent.

He explained also how, by a system of tapes placed in a fixed manner on the head, he had shown the diminution of its round when projected on a plane surface, and that one could read off the relations of every portion of the brain, internal as well as external, to the skin measurements at a glance. He then referred to the many useful applications of the method both for anthropological and many other practical purposes.

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7. *Notes on Classification in Sociology. By* GEORGE WEDDELL.

The study of Social Science has been retarded by misconception as to its nature. It is popularly supposed to consist of a grouping of philanthropic or social movements, such as co-operation, sanitation, technical education, and the better housing of the working classes. By a number of more thoughtful people it is confounded with Political Economy, which ought to be considered only as one of its important branches.

The scope of sociology includes all social phenomena, which, for the purpose of study, may be conveniently grouped into five classes—

1. *Familiar*, including the family and other 'familiar' relations.
2. *Industrial*, including the subject matter of economics.
3. *Political*, including all local or general governmental phenomena.
4. *Cosmical*, or the institutions bearing on:

(A) Investigation (Science),
(B) Imitation (Art), and
(C) Improvement (Adaptation) of Nature
} a. Inanimate, b. Animate (general), and c. Human.

5. *Religious*, including all phases.

This arrangement is based upon the nature of the services rendered to the individual by the various groups, those of the family being most special and immediate, those of religion most general and ultimate. The higher the social organ, the more easily is it referred to its group. For instance, the British Association could not be referred to any other than Class 4, Section A, and embracing sub-sections *a*, *b*, and *c*. The classification proves nothing, and simply serves as a basis for study; but the generalisations we afterwards obtain through it may enable us more clearly to perceive the limits of function in family life, in industry, government, &c.

Sociology might be distinguished from the allied sciences as the study of *man in union with his fellows*—considering the individual as the unit of society or social cell. If we divide the individual we touch upon *biology* (or physiology): if we examine merely varieties of individual type we enter on *anthropology*. In studying combinations of individuals we reach *sociology*.

The scientific conception of society must include and co-ordinate all known social phenomena, not merely those of one class.

The Jewish or Christian conception of society was of a kingdom of God—a religious unity; the old Roman view was that of an empire—a political unity; the modern British idea is of a universal market—an industrial unity. Each of these conceptions evinces a tendency or leading characteristic of peoples in various ages and stages; but each is insufficient as a general view of society.

The conception of the two great masters of sociology, Comte and Spencer, is that society is an organism, built up of individuals, and sustaining its existence by means of organs, comparable in many respects to those by which animal life is carried on. This treatment of the science as organic gives it a unity which was impossible when it was studied through the dry bones of statistics. It supplies the missing link which unites the industrial with the political, and the political with the other organs, while it more clearly distinguishes the functions which each performs in the social body.

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8. *Fire-making in North Borneo.* *By* S. B. J. Skertchly.

The author did not describe any new method of obtaining fire, but his descriptions were offered as exact accounts of the process now in use. The parts of their fire syringes were—cylinder, piston, tinder, tinder-box, and cleaning stick. He explained the length and material of each of these divisions, and the methods of producing fire by fire drills, fire saws, and by means of bamboo and china.

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9. *On some Borneo Traps.* *By* S. B. J. Skertchly.

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10. *The Tribes of South Africa.* *By the* Rev. James Macdonald.

The author, who had lived twelve years among the tribes, referred to the customs relating to property and inheritance, the manner in which they prepare fire, their food, hunting and fishing, agriculture, and war. No cases of murder ever came under his observation except such as were dealt with under English law.

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11. *Report of the Committee for investigating the effects of different occupations and employments on the Physical Development of the Human Body.*—See Reports, p. 186.

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12. *Fifth Report of the Committee for investigating and publishing reports on the physical characters, languages, and industrial and social condition of the North-Western Tribes of the Dominion of Canada.*—See Appendix, p. 797.

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13. *Third Report of the Committee for ascertaining and recording the localities in the British Islands in which evidences of the existence of Prehistoric Inhabitants of the country are found.*—See Reports, p. 318.

APPENDIX.

Fifth Report of the Committee, consisting of Dr. E. B. TYLOR, Dr. G. M. DAWSON, General Sir J. H. LEFROY, Dr. DANIEL WILSON, Mr. R. G. HALIBURTON, *and* Mr. GEORGE W. BLOXAM (*Secretary*), *appointed for the purpose of investigating and publishing reports on the physical characters, languages, and industrial and social condition of the North-Western Tribes of the Dominion of Canada.*

[PLATES X.—XV.]

Remarks on North American Ethnology: Introductory to the Report on the Indians of British Columbia. By HORATIO HALE.

THE Province of British Columbia offers probably the best field of ethnological research now to be found in North America. This distinction is due to two circumstances, each of much importance. The one is the fact that the tribes of this Province have thus far suffered less displacement and change from foreign influences than those of any other region. They still for the most part occupy their original seats, and they retain to a large extent their primitive customs and beliefs. The other circumstance, and one of special scientific interest, is the great number of linguistic stocks, or families of languages, which are found in the Province. There are, as will appear from the report and map, no less than eight of these stocks, being twice as many as now exist in the whole of Europe.

The importance of this fact will be appreciated if we bear in mind that in America the linguistic stock is the universally accepted unit of ethnological classification. It is not that the physical distinctions which have elsewhere been proposed as the basis of classifications are lacking on this continent. On the contrary, they are markedly apparent. In colour the difference is great between the fair-skinned Haidas and Tsimshians of the northern coasts and islands, and the swarthy, almost black, natives of Southern California. Even more notable is the difference between the short, squat, broad-faced, and coarse-featured members of the coast tribes of Oregon and British Columbia, and the tall, slender, oval-visaged Indians of the interior. The striking differences of cranial measurement are shown in Sir Daniel Wilson's work on 'Prehistoric Man.' Hair varying from coarse, straight, and black to fine, brown, and curly; eyes with horizontal and eyes with oblique openings; noses in some tribes aquiline, and in others depressed, show varieties as great as those of colour, stature, and cranial outlines. These and other physical distinctions, however, have not been accepted by any scientific inquirer in America of late years as grounds of classification of the native tribes, for the simple

reason that they are manifestly due to climatic or other local or casual influences, and cannot be held to indicate any difference of race.

But the distinction of linguistic stocks is radical and profound. The differences which it indicates extend far beyond language, and are displayed in the whole nature and character of the speakers of each language. This fact became apparent to me many years ago, in making for the U.S. Government an ethnographical survey of Oregon and of a part of British Columbia.[1] Its existence perplexed me at the time, as it has since perplexed other investigators; and the question of the origin of so many linguistic stocks, or languages radically and totally distinct, found in so limited a district, has appeared to present a problem of the highest scientific interest.[2]

In an address delivered before the American Association for the Advancement of Science in 1886, and published in their volume of 'Proceedings' for that year, I ventured to propose an explanation of the origin, not only of these American languages, but of all stock languages whatsoever, except, of course, the primitive language (whatever it may have been) which was spoken by the first community of the human species. A succinct but clear outline of this theory was given by Professor Sayce in his Presidential Address at the Manchester meeting in 1887. While pointing out what he considered the merits of the theory, Mr. Sayce asked, very reasonably, for more evidence to sustain it than I had been able to include in my brief essay. This evidence I have endeavoured to give in a paper read last year before the Canadian Institute of Toronto, and published in the 'Proceedings' of that society for 1888–89.

With Professor Sayce's address in the hands of the members of the Association, I need only say, briefly, that the theory supposes these isolated idioms to have had their origin in the natural language-making faculty of young children. Many instances of languages thus spontaneously created by children were given; and in my Toronto paper evidence was produced to show that the words and grammar of such languages might, and probably would in many cases, be totally different from those of the parental speech. The fact was pointed out that in the first peopling of every country, when, from various causes, families must often be scattered at very wide distances from one another, many cases must have occurred

[1] 'In the long and narrow section of this continent, included between the Rocky Mountains and the Pacific, and extending from the country of the Eskimo on the north to the Californian Peninsula on the south, there are found perhaps a greater number of tribes speaking distinct languages than in any other territory of the same size in the world. Not only do these tribes differ in their idioms, but also in personal appearance, character, and usages.'—*United States Exploring Expedition under Charles Wilkes, vol. vii. 'Ethnography and Philology:' by Horatio Hale*; 1846; p. 197.

[2] 'It [the map] brings out in a most striking way the singular linguistic diversity which obtains along the west line of this part of America—a fact for which it is indeed difficult to offer a reasonable explanation, knowing as we do how essentially maritime the coast tribes are in their habits, and how skilled and fearless they are in the management of their excellent canoes. The anomaly appears still greater when we contrast the several clearly defined colonies of the coast with the wide sweep of the languages of the interior of the Province, where from the generally rugged and often densely wooded character of the country, and the turbulent nature of the rivers, intercommunication must have been by comparison extremely difficult.'—*Dr George M. Dawson: Preface to 'Comparative Vocabularies of the Indian Tribes of British Columbia; with a Map illustrating Distribution;' by Drs. Tolmie and Dawson*, 1884, p. 7.

where two or more young children of different sexes, left by the death of their parents to grow up secluded from all other society, were thus compelled to frame a language of their own, which would become the mother-tongue of a new linguistic stock. This result, it is clear, would only follow in those regions where, from the mildness of the climate and the spontaneous fruitfulness of the soil, young children would be able to find subsistence for themselves through all seasons of the year.

It is evident that, along with their new language, these children and their descendants would have to frame a new religion, a new social policy, and, in general, new customs and arts, except so far as reminiscences of the parental example and teachings might direct or modify the latter. All these conclusions accord precisely with the results of ethnological investigations in America.

It should, however, be borne in mind that, whether the theory which I thus proposed is accepted or not, the fact will still remain that the existence of a linguistic stock involves the absolute certainty that the tribe speaking such a form of language, differing entirely from all other tongues, must have lived for a very long period wholly isolated from all other communities; otherwise this idiom would not have had time to be formed and to become the speech of a tribe sufficiently numerous and strong to maintain its independence. In this long isolation (however it might arise) the tribe would necessarily acquire by continual intermarriage a peculiar mental character, common to the whole tribe, and with it the modes of thought and the social institutions which are the necessary outcome of such a character. Thus the linguistic stock, whatever its origin, must naturally and necessarily be, as has been said, the proper ethnological unit of classification.

The experience of the able philologists of the American Bureau of Ethnology entirely confirms these views. Special attention, of course, has been given by them to the investigation of the stocks in North America. Mr. J. C. Pilling, of the Bureau, the author of the valuable series of bibliographies of American linguistic stocks now in course of publication, informs me that the number of these stocks in North America (north of Mexico), so far as at present determined, is fifty-eight—a greater number, perhaps, than can be found in the whole eastern hemisphere, apart from Central Africa. Of this number no less than thirty-nine are comprised in the narrow strip of territory west of the Rocky Mountains, which extends from Alaska to Lower California. Why a great number of stocks might naturally be looked for along this coast, with its mild and equable climate, and its shores and valleys abounding in shell-fish, berries, and edible roots, is fully explained in my essays already referred to.

From what has been said it follows that in our studies of communities in the earliest stage, we must look, not for sameness, but for almost endless diversity, alike in languages and in social organisations. Instead of one 'primitive human horde' we must think of some two or three hundred primitive societies, each beginning in a single household, and expanding gradually to a people distinct from every other, alike in speech, in character, in mythology, in form of government, and in social usages. The language may be monosyllabic, like the Khasi and the Othomi; or agglutinative in various methods, like the Mantshu, the Nahuatl, the Eskimo, and the Iroquoian; or inflected, like the Semitic and the Sahaptin. Its forms may be simple, as in the Maya and the Haida, or complex, as in the Aryan, the Basque, the Algonkin, and the Tinneh. The old theo-

retical notion, that the more complex and inflected idioms have grown out of the simpler agglutinative or monosyllabic forms, must be given up as inconsistent with the results of modern researches.

In like manner, we find among primitive communities every form of government and of social institutions—monarchy among the Mayas and the Natchez, aristocracy among the Iroquois and the Kwakiutl, democracy among the Algonkins and the Shoshonees, descending almost to pure, though perhaps peaceful, anarchy among the Tinneh, the Eskimo, and various other families. In some stocks we find patriarchal (or 'paternal') institutions, as among the Salish and the Algonkin; in others, matriarchal (or 'maternal'), as among the Iroquoian and the Haida. In some the clan system exists; in others it is unknown. In some exogamy prevails, in others endogamy. In some, women are honoured and have great influence and privileges; in others, they are despised and ill-treated. In some, wives are obtained by capture, in others by courtship, in others by the agreement of the parents. All these various institutions and usages exist among tribes in the same stage of culture, and all of them appear to be equally primitive. They are simply the forms in which each community, by force of the character of its people, tends to crystallise.

We frequently, however, find evidence, if not of internal development, at least of derivation. Institutions, creeds, and customs are in many cases adopted by one stock from another. As there are now 'loan-words' in all languages, so there are borrowed beliefs, borrowed laws, and borrowed arts and usages. Then, also, there are many mixed communities, in which, through the effect of conquest or of intermarriages, the physical traits, languages, and institutions of two or more stocks have become variously combined and intermingled. In short, the study of human societies in the light of the classification by linguistic stocks is like the study of material substances in the light of their classification by the chemical elements. In each case we find an almost infinite variety of phenomena, some primitive and others secondary and composite, but all referable to a limited number of primary constituents: in chemistry, the material elements; in ethnology, the linguistic stocks. Such is the result of the latest investigations, as pursued on the Western Continent, where for the first time a great number of distinct communities, in the earliest social stages, have been exposed to scientific observation, with all their organisation and workings as clearly discernible as those of bees in a glass hive.

The researches of Dr. Boas, while pursued, as will be apparent, without any bias of preconceived theory, will throw much valuable light on the subjects now referred to, as well as on others of equal importance. It should be added that some of the facts which he has gathered, particularly in regard to the tenure of land among the tribes of British Columbia, have a great practical value. This is a point which deserves special mention, as the Canadian Government is now sharing with the Association the expense of these inquiries. Many of the most costly wars which the Colonial Governments have had to wage with the aboriginal tribes in America, New Zealand, and elsewhere have arisen, as is well known, from misunderstandings growing out of the acquisition of land from the natives. The great benefit which accrued to New Zealand, in the improved relations between the natives and the colonists, from the researches of Sir George Grey into the laws, usages, and traditions of the Maori tribes, is a matter of history. The state of affairs in British

Columbia is in some respects remarkably similar to that which prevailed in New Zealand. If the inquiries which have been instituted by the Association shall have the effect of averting a very possible conflict of races, their utility will be very great—one might almost say incalculable. It may be well, therefore, to draw particular attention to some noteworthy facts set forth in Dr. Boas's report. We learn that the land occupied by certain tribes is held, not by the tribe, nor by individuals, but by the clan, or *gens*, which is consequently the only authority able to dispose of it; and, further, that when the land is sold the original owners are still considered by the native law to retain 'the right of fishing, hunting, and gathering berries in their old home.' It is easy to see how, when these native laws and usages are not understood, collisions might at any time arise, in which each party would naturally claim to be in the right. It should, further, be borne in mind that as there are eight distinct stocks in the Province there may possibly be as many distinct systems of land tenure. At all events, it is certain that the tenure among the tribes in which the clan system exists must differ in one important respect from that of the tribes in which it is unknown.

It is evident that, as Dr. Boas suggests, this branch of inquiry is one which deserves to be carefully prosecuted, both for its scientific interest and for the great practical benefit which may result from it.

First General Report on the Indians of British Columbia. *By* Dr. Franz Boas.

Introductory Note.

The following report on the Indians of British Columbia embodies the general results of a reconnaissance made by the writer in the summer of 1888, under the auspices of the Committee of the British Association appointed for the purpose of collecting information respecting the North-Western Tribes of the Dominion of Canada, supplemented by observations made by the author on a previous trip in the winter of 1886–87. A preliminary report was published in the Fourth Report of the Committee. The present report contains the principal results of the author's investigations on the Tlingit, Haida, Tsimshian, and Kutonaqa (Kootanie). His limited time and the preparations for a new journey to British Columbia, undertaken under the auspices of the Committee, did not permit him to study exhaustively the extensive osteological material collected on the previous journeys. For the same reason the linguistic material collected among the Nootka and Kwakiutl is kept back. Besides this it seemed desirable to await the publication of the grammar of the latter language by the Rev. A. J. Hall in the 'Transactions of the Royal Society of Canada' before publishing the linguistic notes on the same stock, which are necessarily fragmentary when compared to a grammar drawn up by a student who has lived many years among the Indians speaking that language. The chapters on social organisation, customs, art, and knowledge are also necessarily incomplete. The difficulty of observing or even acquiring information on such points during a flying visit of a fortnight—the maximum time spent among any single tribe—is so overwhelming that no thorough report is possible, and it is almost impossible to guard against serious errors. On account of this difficulty the author has paid great attention to the collection of reports

on historical events and of traditions. In these the peculiar customs and character of a people always appear very clearly, and the facts mentioned in these tales form a valuable starting-point for the observation of customs which would else remain unnoticed. Among tribes who have partly yielded to the influence of the contact with whites they afford a valuble clue to their former customs.

The chapter on 'Arts and Knowledge' has not been treated fully, as the general character of North-West American art is well known, and, in order to give a complete account of the conventionalism of the works of art of these tribes, an exhaustive study is necessary, which the writer has been so far unable to undertake.

The author's researches do not include the Tinneh tribes, some of which are comparatively well known. The Salish languages are merely enumerated, as investigations on this interesting stock are being carried on, and the material in its present shape would require an early revision.

The present report is supplemented by the following papers by the author:—

'Zur Ethnologie von Britisch-Columbien.' Petermann's Mittheilungen, 1887. No 5, with map.

'Mittheilungen über die Bilqûla Indianer.' Original Mittheilungen aus dem Museum für Völkerkunde, Berlin, pp. 177–182, with two plates.

'Die Sprache der Bilqûla.' Verh. anthrop. Ges. Berlin, 1886, pp. 202–206.

'Census and Reservations of the Kwakiutl.' Bull. Am. Geogr. Soc. Sept. 1887.

'On Certain Songs and Dances of the Kwakiutl.' Journ. Am. Folk-Lore, 1888, pp. 49–64.

'Chinook Songs.' Journ. Am. Folk-Lore, 1888, pp. 220–226.

'Die Tsimschian.' Ztschr. für Ethnologie, Berlin, 1888, pp. 231–247.

'The Houses of the Kwakiutl Indians.' Proc. U.S. National Museum, 1888, pp. 197–213.

'Notes on the Snanaimuq.' Am. Anthropologist, Washington, 1889, pp. 321–328.

'The Indians of British Columbia.' Trans. Roy. Soc. of Canada, 1888, Sec. II. pp. 47–57.

'Die Mythologie der nordwestamerikanischen Küstenstämme.' Globus, Braunschweig, 1887–88.

The following alphabet has been used in the report:—

The vowels have their continental sounds, namely: *a*, as in *father*; *e*, like *a* in *mate*; *i*, as in *machine*; *o*, as in *note*; *u*, as in *rule*.

In addition the following are used: *ä*, *ö*, as in German; *â*=*aw* in law; *E*=*e* in *flower* (Lepsius's *e̥*).

Among the consonants the following additional letters have been used: *g·*, a very guttural *g*, similar to *gr*; *k·*, a very guttural *k*, similar to *kr*; *q*, the German *ch* in *bach*; *H*, the German *ch* in *ich*; *Q*, between *q* and *H*; *c*=*sh* in *shore*; *ç*, as *th* in *thin*; *tl*, an explosive *l*; *dl*, a palatal *l*, pronounced with the back of the tongue (dorso-apical).

Character of the Country.

The north-west coast of America, from Juan de Fuca Strait to Cross Sound in Alaska, is characterised by its fiords, sounds, and islands, which make it very favourable for navigation in canoes and other small craft.

Among the most important of these fiords is Portland Inlet, in the extreme north of the territory. Near its mouth Nass River empties itself, which is navigable for canoes for about 80 miles. Between the 55th and 54th degrees of latitude the coast is comparatively open. Here the Skeena River has its mouth. Farther south we find an extremely intricate network of fiords and channels, some of which penetrate far into the interior. Among these we may mention Gardner and Douglas Channels, Dean Inlet, and Bentinck Arm, and the straits and sounds separating Vancouver Island from the mainland. This region has a very temperate climate, the heat of summer and the cold of winter being moderated by the influence of the sea winds. This influence, however, does not extend far inland, and a few miles from the sea-coast low temperatures prevail in winter. While intercourse all along the coast is greatly facilitated by its character, it is almost impossible to penetrate into the interior, the high peaks of the coast ranges rising abruptly from the sea. There are only a few passes by means of which intercourse is possible. The most important of these are on Skeena River, and on Salmon and Bella Coola Rivers of Dean Inlet and Bentinck Arm.

As the precipitation all along the coast is very great, its lower parts are covered with dense forests, which furnish wood for building houses and canoes. Among these, the pine, hemlock, and the red and yellow cedar are the most prominent; while the hard wood of the maple is used for implements of various kinds, principally for paddles. The woods abound with numerous kinds of berries, which are eagerly sought for by the Indians. They also make use of the kelp and seaweed with which the sea abounds.

In the woods the deer, the elk, the cariboo, the black and the grizzly bears, the wolf, and numerous other animals, are found. The mountain goat lives on the high mountain ranges. The beaver, the otter, and the fur-seal furnish valuable skins. The Indians keep a great number of dogs in their villages, which look almost exactly like the coyote. In the northern villages they are much like the Eskimo dog.

Of prime importance to the natives is the abundance of fish and other animals living in the sea. Seals, sea-lions, and whales are found in considerable numbers, but the Indian depends almost entirely upon the various species of salmon and the olachen (*Thaleichthys pacificus*, Gir.), which are caught in enormous quantities in the rivers. Various species of cod and halibut are caught throughout the year; herrings visit the coast early in spring; in short, there is such an abundance of animal life in the sea that the Indians live almost solely upon it. Besides fish, they gather several kinds of shell-fish, sea-eggs, and cuttle-fish.

The interior of the Province is throughout mountainous, with the exception of a portion of the territory occupied by the Tinneh. The country east of the coast ranges is comparatively dry, hot in summer and cold in winter. The southern parts of this region are desolate, the rivers cutting deep gorges through the valleys, which are filled with drift. Agriculture can be carried on only by means of irrigation, but the country is well adapted to stock-raising. Salmon ascend the rivers, and the lakes are well stocked with fish, which forms the staple food of the tribes west of the Selkirk Range. Between this range and the Rocky Mountains the wide valley of the Columbia and Kootenay Rivers extends from the International Boundary to near the great bend of the Columbia. The Indians of this valley have access to the great plains over a number of passes.

INHABITANTS.

The country is inhabited by a great number of tribes belonging to seven or eight linguistic stocks. Certain similarities of form and phonetic elements between the Tlingit and Haida languages have given rise to the opinion that further researches may show them to be remote branches of the same stock. This presumption might appear to be strengthened by their divergence from all other stocks inhabiting the territory. Nevertheless the dissimilarity of vocabularies and of grammatical elements is so great that the coincidences referred to cannot yet be considered sufficient proof of their common origin, although the two languages must be classed together in one group when compared with the other languages of the North Pacific coast. Counting them for the present as separate stocks, we distinguish the following families:—

1. Tlingit.—Inhabiting Southern Alaska.
2. Haida.—Inhabiting Queen Charlotte Islands and part of Prince of Wales Archipelago.
3. Tsimshian.—Inhabiting Nass and Skeena Rivers and the adjacent islands.
4. Kwakiutl.—Inhabiting the coast from Gardiner Channel to Cape Mudge, with the sole exceptions of the country around Dean Inlet and the west coast of Vancouver Island.
5. The Nootka.—Inhabiting the west coast of Vancouver Island.[1]
6. The Salish.—Inhabiting the coast and the eastern part of Vancouver Island south of Cape Mudge, the southern part of the interior as far as the crest of the Selkirk Range and the northern parts of Washington, Idaho, and Montana.
7. The Kutonāqa.—Inhabiting the valley of the Upper Columbia River, Kootenay Lake and River, and the adjoining parts of the United States.

The Tlingit, although not belonging properly to British Columbia, have been included in this report, as they must be considered in a study of the Haida and Tsimshian.

I do not enumerate the tribes composing the Tlingit and Haida peoples, as the former have been treated by Dr. A. Krause in his excellent work, 'Die Tlinkit Indianer,' while I am not acquainted with the subdivisions of the latter. Dr. G. M. Dawson in his 'Report on the Queen Charlotte Islands' gives a list of villages. It seems that the Haida divide their people into several groups, each group comprising a number of villages. The Haida call themselves Qā′eda, i.e. people. They are called by the Tlingit Dēkyinō′, i.e. people of the sea. The Tsimshian call them Haida, which is evidently derived from Qā′eda.

The following list of Tsimshian tribes was obtained by inquiries at the mouth of Skeena River.

The language is spoken in two principal dialects, the Nasqa′ and the Tsimshian proper.

I. Tribes speaking the Nasqa′ dialect:

1. Nasqa′, on Nass River.
2. Gyitksa′n, on the upper Skeena River=people of the Ksia′n.

[1] New observations made in 1889 seem to indicate that there exists an affinity between the fourth and fifth groups.

II. Tribes speaking the Tsimshian proper:

1. Ts'ᴇmsia'n, on the mouth of Skeena River=on the Ksia'n.
2. Gyits'umrä'lon, below the cañon of Skeena River=people on the upper part of the river.
3. Gyits'ala'ser, at the cañon of Skeena River=cañon people.
4. Gyitqā'tla, on the islands off the mouth of Skeena River=people of the sea.
5. Gyitg·ā'ata, on the shores of Grenville Channel=people of the poles, so called on account of their salmon weirs.
6. Gyidesdzo', north-west of Milbank Sound.

Some of these tribes are subdivided into septs, each of which inhabits one village (see 'Ztschr. für Ethnologie,' 1888, p. 232).

The Tsimshian are called by the Tlingit Ts'ōtsǫᴇ'n; by the Hēiltsuk· Kwē'tᴇla; by the Bilqula, Elqī'miн; while the Haida designate each tribe by its proper name.

The whole people is divided into four clans: the *raven*, called K·anha'da; the *eagle*, called Laqskī'yek; the *wolf*, called Laqkyebō'; and the *bear*, called Gyīspōtuwᴇ'da. Details on this subject will be found in the chapter on social organisation.

4. The Kwakiutl.—So far as I am aware, the language is spoken in three dialects, the people speaking them not being wholly unintelligible to each other: the Qāisla', the Hēiltsuk·, and the Kwakiutl proper. The Qāisla' is spoken north of Grenville Channel; the Hēiltsuk· embraces the tribes from Grenville Channel to Rivers Inlet; the Kwakiutl proper is spoken from Rivers Inlet to the central part of Vancouver Island. I do not enter into an enumeration of the many tribes of this group, one list having been published by Dr. George M. Dawson in the 'Transactions of the Royal Society of Canada,' 1887, another, accompanied by a detailed map by the writer, in Petermann's 'Mittheilungen,' 1887.

The most northern tribe of this group, the Qāisla', are called Gyit'amā't by the Tsimshian; the Gyimanoitq of Gardner Channel are called Gyitlō'p by the same people. The Hēiltsuk· proper are called Wutsta' by the Tsimshian, ᴇlk·la'sumн by the Bilqula.

5. Nootka.—Regarding their tribal divisions I would refer to Sproat's 'Scenes and Studies of Savage Life.' The Pᴇ'ntlatc call the Nootka Çōlē'itc, but as a rule this name is used for the tribes of Alberni Channel only. The Çatlō'ltq call these tribes Ō'menē, the Sk·qō'mic call them Tc'ᴇcā'atq. (Detailed information on the tribes of this stock will be given in the report for 1890.)

6. The Salish.—This important stock, which inhabits a large part of British Columbia and the adjacent territories of the United States, is represented by two groups of tribes on the coast of the province:—

A. The Bilqula of Dean Inlet and Bentinck Arm, comprising four tribes.

B. The Coast Salish.—I comprise in this group the numerous dialects of the Salish stock that are spoken on the coasts of the Gulf of Georgia and of Puget Sound. The difference between these tribes and those of the interior, in regard to their mode of life and language, is so marked that we may be allowed to class them in one large group. H. Hale and A. Gallatin first pointed out their affinities to the Salish proper. A number of tribes of Puget Sound are included under the name of Niskwalli (more properly, Nsk·oa'li), but it seems to me that the subdivisions of the

latter are not perfectly known. The Niskwalli would properly form one of the larger divisions of the Coast Salish. The latter is spoken in the following dialects in British Columbia:—

1. Çatlō'ltq, in Discovery Passage, Valdes Island, Bute and Malaspina Inlets. The Çatlō'ltq are called K·ō'moks by the Lē'kwiltok·.

2. Sī'ciatl, in Jervis Inlet. Called Sī'cätl by the Snanaimuq, Nī'ciatl by the Çatlō'ltq.

3. P·E'ntlatc, from Comox to Qualekum.

4. Sk·qō'mic, on Howe Sound and Burrard Inlet. Called Sk·qoā'mic by the Çatlō'ltq.

5. K·au'itcin, from Nonoos Bay to Sanitch Inlet, and on Fraser River as far as Spuzzum.

6. Lku'ngEn, on the south-eastern part of Vancouver Island. Called Lkū'mEn by the K·au'itcin.

Similar to their language is the Tla'lEm of the south coast of Juan de Fuca Strait; the S'ā'mic, which is spoken east of San Juan Island; the Semiā'mō of Semiamo Bay, and the Qtlumi (Lummi).

C. Ntlakya'pamuQ, from Spuzzum to Ashcroft.

D. Stla'tliumH, on Douglas and Lilloet Lakes.

E. SQua'pamuQ, from Kamloops and Shushwap Lakes to Quesnelle. Called Tlitk·atEwū'mtlat by the Kutona'qa (= without shirts and trousers).

F. Okinā'k·ēn, on Okanagan and Arrow Lakes. Called TcitQuā'ut by the Ntlakya'pamuQ; Kānk·'utlā'atlam (= flatheads) by the Kutona'qa.

7. The Kutona'qa (Kootenay), inhabiting the valley of the Kootenay and Columbia Rivers. The language is spoken in two slightly differing dialects, the upper and lower Kootenay.

I. Upper Kootenay, on the Columbia Lakes and upper Kootenay River.

(1) Aqkisk·anū'kEnik, = tribes of the (Columbia) lakes.
(2) Aqk'a'mnik, at Fort Steele.
(3) Aqk'anequ'nik (= river Indians), Tobacco Plains.
(4) Aqkīyē'nik, Lake Pend d'Oreille.

II. Lower Kootenay.

Aquqtlā'tlqō, Aquqenu'kqō; Kootenay Lake.

The Kutona'qa call the Blackfeet Sahā'ntla = bad Indians; the Cree, Gutskiau'm = liars; the Sioux, Katsk·agi'tlsāk = charcoal legs.

The census returns of the Indian Department give the following numbers for the various peoples. The Tlingit are not included in this list, as they do not live in British territory.

—	1883	1884	1885	1886	1887	1888
Haida, Kaigani excepted (estimated)	—	—	—	—	—	2,500
Tsimshian (estimated)	—	—	—	—	—	5,000
Bilqula and Hēiltsuk· (estimated)	—	—	—	—	—	2,500
Nootka	3,612	3,437	3,445	3,415	3,361	3,160
Kwakiutl and Lēkwiltok·	2,264	1,889	1,969	1,969	1,936	1,898
Coast Salish	—	6,605	6,874	7,080	6,724	6,838
Ntlakyapamuq, Stla'tliumH, and SQua'pamuQ	5,791	5,470	4,740	4,649	4,655	4,497
Okinā'k·ē	1,188	1,188	1,020	1,004	956	942
Kutona'qa	—	—	—	—	568	587

These figures show that the census is approximate only. The inland

tribes appear to be decreasing in numbers, while the coast tribes appear to be almost stationary. The above list gives a total of about 27,900. To these must be added 1,500 Tinneh and 8,522 'bands not visited,' whoever these may be.

The Indians of the interior have almost entirely given up their ancient customs. They are mostly Roman Catholics, but there are a few Protestants. Of course a considerable amount of paganism is still lurking under the Christianism of these natives. They are good stock-raisers, and endeavour to irrigate their lands; but it seems that the majority are poor. The lower Kutona'qa still adhere, to a great extent, to their ancient customs. They are principally fishermen. All the Salish tribes catch a considerable amount of fish, while the upper Kutona'qa were originally hunters.

The coast Indians are well off up to this day. While the efforts of missionaries among the Haida have so far not been very successful, the Tsimshian proper have become Christianised. They have given up all their old customs except those referring to their social organisation. The gentes are still acknowledged, and the laws referring to the mutual support among members of one gens and to the work to be done by the father's gens at certain occasions (see p. 837) are still in force. The final giving up of customs seems to be done by the council, not by the individuals. The Hēiltsuk· have been Protestants for many years, while the Bilqula are still uninfluenced by contact with missionaries. The same is true, to a large extent, among the Kwakiutl, only a few individuals of the Nimkic tribe adhering to the Episcopalian Church. The Coast Salish belong in part to the Roman Catholic Church; but notwithstanding their allegations paganism still prevails to a great extent. In the report of the Department of Indian Affairs almost all of them are enumerated as Roman Catholics, even the pagan tribes of Comox, Victoria, and Nanaimo, where their old customs are still rigidly adhered to. Among the Nootka the Roman Catholics have gained considerable influence.

In my preliminary report I have dwelt upon the present state of these Indians, the causes of their discontent, and the incapacity of white settlers to understand the peculiar culture of the Indian. The establishment of industrial schools, which is now taken up energetically, is a great step forward, and will help the Indians to reach independence and to retain or regain self-esteem, one of the foundations of progress. I will not repeat the statements made and the views expressed last year. It is to be hoped that by a considerate land policy, by the encouragement of industries rather than of agriculture, and by an attempt to develop existing institutions instead of destroying them the Indians will in course of time become useful men and good citizens.

Physical Character.

The physical characteristics of the coast tribes are very uniform. This is undoubtedly due to the frequent intermarriages between the various tribes, which have had also a distinct effect upon the various languages, some of which have borrowed great numbers of words from the languages spoken by neighbouring tribes. I shall refer to this fact later on. The habitus of the northern tribes of this region is similar to that of East Asiatic tribes—a fact which was observed by R. Virchow, who

examined a number of Bilqula who visited Berlin in the winter of 1885–86. This similarity is very marked among the Tlingit, Haida, Tsimshian, Kwakiutl and Bilqula, to a less extent among the Nootka, while the Coast Salish and the Salish of the interior show a different type. As the Bilqula speak a language belonging to the Salish family, it must be assumed that they acquired their distinct physical character through intermixture with the neighbouring tribes.

Many tribes of this region are in the habit of deforming the heads of their children. I noticed three different methods of deformation. The tribes of the northern part of Vancouver Island use circular bandages by means of which the occiput acquires an extraordinary length. Excessively deformed heads of this kind are found on the northern part of the west coast of Vancouver Island among the K'oskī'mō. Farther south a strong pressure is exerted upon the occiput, a bandage is laid around the head immediately behind the coronal suture, and a soft cushion is used for pressing down the forehead. The Flatheads proper compress forehead and occiput by means of boards or hard cushions. It seems that the Tlingit, Haida, and Tsimshian never practised the custom of head-flattening. It is unfortunate that no observations on the Tsimshian of the upper Skeena River exist. Those at the mouth of the river have frequently intermarried with the Tlingit, Haida, and Hēiltsuk'.

Among the Tlingit, Haida, Tsimshian and Hēiltsuk' the custom prevails of perforating the lower lips of the females. In these perforations, which are enlarged with increasing age, labrets are worn, which are in some instances as long as 40mm. and as wide as 20mm. The men of all the coast tribes have the septum perforated, the operation being performed in early childhood. Earrings are worn either in a series of perforations of the helix or in the lobe of the ear.

Chiefs' daughters, among the Tsimshian, have the incisors ground down to the gums by chewing a pebble of jade, the row of teeth thus assuming an arched form.

Among the Nootka scars may frequently be seen running at regular intervals from the shoulder down the breast to the belly, and in the same way down the legs and arms. Tattooings are found on arms, breast, back, legs, and feet among the Haida; on arms and feet among the Tsimshian, Kwakiutl, and Bilqula; on breast and arms among the Nootka; on the jaw among the Coast Salish women.

Members of tribes practising the Hamats'a ceremonies (see p. 851) show remarkable scars produced by biting. At certain festivals it is the duty of the Hamats'a to bite a piece of flesh out of the arms, leg, or breast of a man.

The women of the Kwakiutl tribes wear very tight anklets, which prevent free circulation between feet and legs. These anklets leave lasting impressions.

Before describing the general features of these tribes I give a table of measurements. Unfortunately I was not in possession of a *glissière*, and therefore no great weight is attributed to the measures, which ought to be made with that instrument. A T-square, to which a movable arm was attached, was used as a substitute. The seven individuals, all male, were measured in the jail at Victoria, kind permission having been given by Major Grant. I did not consider it advisable to make anthropometrical measurements in the villages of the natives, as I feared to rouse their distrust, and had nowhere time to become well acquainted with them. It

is almost impossible to use profitably a very short time for both anthropometrical and ethnological collections.

The following individuals were measured:—

Haida: 1. Gētgalgā'o (Samuel), 25 years old; raven gens; native of Coal Harbour.

2. Johnny Dixie, *circ* 50 years old; native of Skidegate.

Tsimshian: 3. Johnny, *circ.* 32 years old; native of Fort Simpson.

4. William Seba'sa, *circ.* 28 years old; raven gens; native of Meqtlakqatla.

5. Peter Vann, Kesuwā'tk, *circ.* 25 years old; wolf gens; native of Meqtlakqatla.

Kwakiutl: 6. Nalakyutsa, *circ.* 50 years old; native of Fort Rupert.

Nootka: 7. Wispu, *circ.* 25 years; Nitinath.

—	Haida		Tsimshian			Kwakiutl	Nootka
	Samuel Gētgalgāō from Coal Harbour, 25 years	Johnny Dixie from Skidegate, *circa* 50 years	Johnny, 32 years, Fort Simpson	William Seba'sa,' Meqtlakqatla, 28 years	Peter Vann, Kesuwā'tk Meqtlakqatla, 25 years	Nalakyutsa from Fort Rupert, *circa* 50 years	Wispu from Nitinath, *circa* 25 years
I. Head.							
	mm.	mm.	mm.	mm.	mm.	mm.	mm.
Maximum length	192	203	201	192	199	206	189
Maximum width	149	159	154	160	159	175	162
Height of ear	149	—	127	127	126	130	135
Chin to hair	196	213	203	201	188	200	190
Chin to root of nose	130	118	128	126	122	121	127
Root of nose to mouth	76	86	90	81	74	81	78
Width of face between zyg. arch.	154	142	151	146	151	138	152
„ „ angles of jaw	114	—	102	104	114	—	122
„ of sup. max. bone	105	108	121	112	112	105	117
Distance of edges of orbits	107	120	108	108	113	121	121
„ inner corners of eyes	38	37	38	35	38	38	40
„ outer corners of eyes	95	96	98	95	98	92	99
Chin to tragus	146	150	156	152	144	152	156
Tragus to root of nose	112	112	124	119	114	107	129
Nose, height	58	—	57	62	54	54	60
„ width	38	41	38	33	38	35	41
Mouth, length	56	57	56	56	54	57	59
Ear, height	76	76	73	70	67	71	67
Horizontal circumference	581	—	—	578	603	—	—
Vertical circumference from ear to ear	358	—	—	365	341	—	—
II. Indices.							
Length-width index	77·6	78·3	76·6	83·3	79·9	85·0	85·7
Height of ear index	77·6	—	63·2	66·1	63·3	63·1	71·4
Facial index	84·4	83·1	84·1	86·3	80·8	87·7	83·6
Nasal index	65·5	—	66·6	53·2	70·4	64·8	68·3

—	Haida		Tsimshian			Kwa-kiutl	Nootka
	Samuel Gētgalgāō from Coal Harbour, 25 years	Johnny Dixie from Skidegate, *circa* 50 years	Johnny, 32 years, Fort Simpson	William Seba'sa, Meqtlakqatla, 28 years	Peter Vann, Kesuwā'tk, Meqtlakqatla, 25 years	Nalakyutsa from Fort Rupert, *circa* 50 years	Wispu from Nitinath, *circa* 25 years
III. Body.							
Total height	1,689	1,603	1,637	1,649	1,589	1,575	1,711
Distance between finger-tips, the arms extended horizontally	1,705	1,692	1,727	—	1,676	1,664	1,829
Height of chin	1,441	1,353	1,413	1,405	1,356	1,343	1,470
„ top of sternum	1,365	1,287	1,306	1,317	1,278	1,273	1,391
„ shoulder (right)	1,382	1,311	1,313	1,329	1,321	1,292	1,403
„ „ (left)	—	1,286	—	—	—	—	—
„ elbow (right)	1,071	968	1,007	1,025	995	965	1,065
„ wrist	825	752	768	826	776	760	814
„ second finger	612	570	571	614	597	571	618
„ nipples	1,210	1,105	1,143	1,205	—	1,133	1,230
„ navel	970	913	933	946	876	897	985
„ crista ilii	940	930	930	943	905	933	—
„ symphysis	—	835	851	—	—	832	—
„ perinæum	—	711	721	—	—	714	—
„ ant. sup. iliac spine	—	873	870	892	857	851	—
„ trochanter	861	841	829	825	—	—	—
„ patella	444	444	400	427	438	429	—
„ malleolus internus	—	86	83	—	—	89	—
„ seventh vertebra	—	1,362	—	1,400	1,353	1,299	1,475
„ vertex in sitting	—	873	876	—	—	873	914
Width between iliac spines	—	267	267	—	—	—	—
„ iliac crests	—	292	298	—	—	283	—
„ trochanters	—	314	314	—	—	289	—
Circumference of chest	910	930	960	940	950	925	945
„ waist	800	815	822	822	825	860	727
„ thigh	—	508	524	—	—	480	—
„ calf of leg	—	311	355	—	—	310	—
Length of thumb	67	65	60	63	57	63	65
„ second finger	98	101	97	97	97	98	98
Width of hand at fingers	84	82	82	84	85	84	78
Length of foot	243	245	241	236	—	245	251

It appears from these tables that the size of these Indians varies considerably; including measurements of nine Bilqula, made by R. Virchow (see 'Verh. Ges. f. Anthr., Ethn. u. Urg.' 1886, p. 215), the average height is 1,655 mm., the extremes being 1,743 mm. and 1,542 mm. I am under the impression that, as regards size, the Coast Salish are much smaller than the other tribes. The distance between the tips of the finger, the arms being extended, is in all cases greater than the total height. The skin is very light, resembling that of Europeans. Only No. 6 of the above table has a somewhat reddish hue. This, however, is due to the fact that he is the only one among the individuals measured who does not wear trousers and shirt, but still adheres to the ancient custom of wearing a blanket. In most cases the hair is black, smooth, coarse, and

abundant. In a few cases it has a brownish tinge. In all tribes there are a few individuals who have slightly wavy hair. In the village of Sâ'menos, in Cowitchin Valley, I observed wavy or even curly hair comparatively frequently. It is worth remarking that the Indians have a tradition referring to this fact, which shows that this peculiarity has obtained for several generations. The eyebrows are thick, and remarkably wide on the outer side. This peculiarity may also be observed in the carvings of these tribes. The eyebrows are carefully trimmed. The beard is sparse, but it must be remembered that the hair is generally pulled out as it appears, particularly on the cheeks, while the moustache and the chin-tuft are allowed to grow. The iris is dark brown. Virchow first pointed out the frequent occurrence of the *plica interna*. I found it to occur very generally, particularly among the Haida and Tsimshian. The face is wide, the cheek-bones prominent, the index chamæprosopic, averaging (including Virchow's measures) 83·1. The nose is narrow, the root narrow and depressed. The ridge of the nose is frequently depressed, particularly among the Haida and Tsimshian; while among the Nootka, Kwakiutl, and Salish I observed very generally straight or slightly hooked noses. It seems that the heads of the southern tribes are decidedly more brachycephalic than those of the northern tribes; but it is difficult to decide how far that is due to artificial deformation.

From the limited material at my disposal, I do not venture to describe any physical features as characteristic of one tribe or the other. The frequent intermarriages between the various tribes make it probable that none of them shows peculiar somatological characteristics which do not occur also among the neighbouring tribes. Notwithstanding this fact, it is quite possible to distinguish individuals belonging to various tribes, but this is principally due to the variety of artificial deformations. The Kwakiutl have a remarkably deep sinus in the hair at its anterior margin. Their heads are very long and wide, particularly when compared with the width of the face.

I am unable in the present report to give a full description of the crania and skeletons I collected; the latter belong principally to tribes of the Salish stock. I have only a single Tsimshian cranium, which, however, is of some interest. Plates X. to XV. are orthogonal tracings of four Tsimshian crania. Nos. XI. to XIII. are from the Morton Collection in the Museum of the Academy of Natural Sciences at Philadelphia. The measurements of this series of crania are given in the table on the following page.

Notes.—No. X. was a syphilitic individual. Marks of the disease are seen particularly around the bregma and on the right parietal bone. The cranium is asymmetrical, more particularly the occiput. The sagittal suture in its hind part is depressed, while slight indications of a ridge may be seen in the part immediately behind the bregma. The face is narrow as compared to the other specimens. The grooves of the lachrymal duct are comparatively small. The most peculiar feature of the present skull is its dental and alveolar prognathism of the upper row of teeth, which project considerably over the lower one.

Nos. XI., XII., and XIII. show very marked sagittal ridges. There is no indication of premature synostosis, and I conclude that this must be considered a characteristic feature of these skulls. No. XII. has a flattened occiput, but without any compensatory flattening of the forehead. This

shows that the flattening is not intentional, but merely the result of the hardness of the cradle board on which the child was kept. The occipital spine and protuberance of No. XII. are very strongly developed, but they are very marked in all the crania. The vertical plate of the ethmoid bone and the nasal process of the maxillary bones are in Nos. XI. and XII. much distorted.

Tsimshian.

—	I. Boas, No. 85. Male	II. Philadelphia, No. 213. Male	III. Philadelphia, No. 214. Female	IV. Philadelphia, No. 987. Youth, about 18 years of age
CRANIA.				
1. Horizontal length	176	188	176	177
2. Maximum length	176	190	176	178
3. „ width	135	147	135	147
4. Minimum width of forehead	89	91	87	95
5. Total height	130	134	127	129
6. Height of ear	110	112	112	112
7. Length of basis	95	109	100	95
8. Width of basis	99	119	106	102
9. Length of pars basilaris	29	32	31	25
10. Max. width of For. Magn.	32	33	28	30
11. Max. length of For. Magn.	43	38	35	36
12. Horizontal circumference	500	—	—	520
13. Sagittal circumference	363	—	—	366
14. Vertical circumference	301	—	—	330
15. Width of face	97	106	105	90
16. Width between zygm. arches	126	149	139	124
17. Height of upper face	69[1]	81	69	65
18. Height of nose	49	57	52	49
19. Max. width of nose	26	24	25	22
20. Width of orbit	38	41	40	41
21. Height of orbit	32	36	35	36
22. Length of palate	50	59	54	(45)
23. Width of palate at second molar	35	38	38	35
24. Width of palate at posterior end	40	—	47	42
25. Length of face	96	102	98	95
26. Angle of profile	83°	88°	86°	—
INDICES.				
Length—width	76·7	78·2	76·7	83·0
Length—height	73·9	71·3	72·1	72·9

I do not intend, in the present report, to treat of the deformed crania of the southern tribes. Suffice it to say that three methods of deformation are practised in British Columbia: (i) the conical one, which results in the long heads of the Kwakiutl, and which is also used by the Çatlōltq; (ii) the flattening by means of cushions and bandages, resulting in asymmetrical hyperbrachycephalic heads; and (iii) flattening by means of boards. It may be of interest to show the effect of these methods upon the length and width of the crania. The second group comprises only crania flattened by means of cushions. I add a short column of crania with little or no deformations.

[1] Height of face, 116.

	1. Comox		2. Sanitch		3. Songish	
	Length	Width	Length	Width	Length	Width
	171	150	158	158	192	144
	181	149	160	147	186	144
	173	138	171	153	183	142
	162	131	162	158	176	139
	179	145	141	152	178	144
	177	135	161	156	190	147
	178	143	156	155	189	143
	186	147	147	138	180	140
	171	138	156	137	180	140
	174	139	169	164	187	146
	175	142	164	163	195	157
Average . .	175	142	159	153	185	144
Indices . .	81·1		96·2		77·8	

The following are measurements of a few Songish crania in the possession of Dr. Milne, of Victoria, British Columbia.

Songish Crania.

—	I.	II.	III.
1. Horizontal length	183	—	181
2. Maximum length	183·5	153	181
3. Intertuberal length	182·5	146	180
4. Maximum width	139·8	154·6	154
5. Minimum width of forehead . .	98	98	97
6. Total height	143·2	123·2	138·5
7. Height of bregma	141	122·3	137
8. Height of ear	114	106	117
9. Height from ear to vertex . .	114	114[1]	123
10. Length of basis	103	89	101
10*a*. Width of basis	111·2	106	118
11. Length of pars basilaris	—	23·5	29
12. Max. width of foramen magnum .	33	34	37·5
13. Max. length of foramen magnum .	34·5	29	34
14. Horizontal circumference . .	523	485	535
15. Sagittal circumference . . .	375	321[2]	382
16. Vertical circumference . . .	320	328	335
17. Width of face	105	91·5	103
18. Width between zygom. arch . .	146	130	148·5
19. Height of face	—	101·5	—
20. Height of upper part of face . .	72·5	61	76
21. Height of nose	50	47	54
22. Max. width of nose	22·7	22	26·5
23. Max. width of orbit	42	38·5	44
24. Horizontal width of orbit . .	41·5	38	41
25. Maximum height of orbit . .	36·5	35	37·5
26. Vertical height of orbit . . .	37	35	36
27. Length of palate	49	45	51·5
28. Width of palate at second molar .	34	35	41
29. Width of palate at posterior end .	46	39	47
30. Length of face	102	88	100

[1] Vertex 25 mm. behind bregma.
[2] 124 Sut. nas. front. to bregma, 222 Lambda, 248 interparietal sut.

Finally, I give a series of measurements of seven crania from Lytton, probably of the Ntlakyapamuq, collected a number of years ago by Dr. G. M. Dawson, who kindly had the measurements made at my request.

Skulls from Lytton B. C. in the Museum of the Geological and Natural History Survey of Canada.

—	No. 368	No. 369	No. 370	No. 371	No. 372	No. 373	No. 374
1. Maximum length . . .	174	185	167	173	182	175	173
2. Horizontal length . .	173	—	167	172	181	175	169
3. Maximum width . .	139	140	138	139	131	144	132
4. Minimum width of forehead	94	96	91	86	94	96	93
5. Total height . . .	127	—	132	131	135	134	134
6. Height of ear . . .	111	—	92	110	121	123	120
7. Length of basis . . .	99	—	97	96	99	103	102
8. Horizontal circumference .	497	516	485	497	506	516	494
9. Sagittal circumference .	346	375	346	358	386	349	346
10. Vertical circumference .	314	321	305	307	307	324	311
11. Width of face . . .	107	—	112	115	111	122	—
12. Width between zyg. arch .	—	—	—	127	135	—	—
13. Height of face . . .	62	—	68	72	64	69	64
14. Height of nose . . .	51	—	52	55	49	40	47
15. Width of nose . . .	21	—	23	25	23	26	22
16. Angle of profile . . .	88°	—	79°	80°	88°	85°	82°
Length—width—index .	80·4	75·7	82·6	80·4	72·4	82·3	78·1

Senses and Mental Characters.

It is only with a considerable degree of diffidence that I venture to express an opinion on the senses, mental capacity, and character of the natives of British Columbia. Observations made in the course of a few days hardly entitle an observer to judge of the mental faculties or of the virtues and vices of a people. The only tribes with whom I came into closer contact are the Tlatlasik·oala of Hope Island and the Çatloltq of Comox, among both of whom I lived for a few weeks in 1886.

The Indians of the whole coast are able-bodied and muscular, the upper limbs being very generally better developed than the lower ones, as the constant use of the paddle strengthens arms and chest. They have a keen sight, but in old age become frequently blear-eyed, presumably an effect of the smoke which always fills the houses. I have not made any experiments regarding their acuteness of sight, hearing, and smell. Their mental capacity is undoubtedly a high one. The state of their culture is ample proof of this. I have expressed my opinion regarding the possibility of educating them at another place.

The best material for judging their character is contained in their stories, in which appears what is considered good and what bad, what commendable and what objectionable, what beautiful and what otherwise. Regarding the last point, whiteness of skin and slenderness of limbs is considered one of the principal beauties of men and women. Another beauty of the latter is long, black hair. In some tales red hair is described as a peculiar beauty of women. Red paint on the face, tight-fitting bracelets and anklets of copper, nose- and ear-ornaments of variegated haliotis shells, and hair strewn with eagle-downs add to the

natural charms. The fact that in honour of the arrival of friends the house is swept and strewn with sand, and that the people bathe at such occasions, shows that cleanliness is appreciated. The current expression is that the house is so cleaned that no bad smell remains to offend the guest. For the same reason the Indian takes repeated baths before praying, 'that he may be of agreeable smell to the Deity.'

The Indian is grave and self-composed in all his actions. This is shown by the fact that playing is not only considered undignified, but actually as bad. In the Tsimshian language the term for 'to play' means to talk to no purpose; and doing anything 'to no purpose' is contemptible to the Indian.

He is rash in his anger, but does not easily lose control over his actions. He sits down or lies down sullenly for days without partaking of food, and when he rises his first thought is, not how to take revenge, but to show that he is superior to his adversary. A great pride and vanity, combined with the most susceptible jealousy, characterise all actions of the Indian. He watches that he may receive his proper share of honour at festivals; he cannot endure to be ridiculed for even the slightest mistake; he carefully guards all his actions, and looks for due honour to be paid to him by friends, strangers, and subordinates. This peculiarity appears most clearly in great festivals, which are themselves an outcome of the vanity of the natives, and of their love of displaying their power and wealth. To be strong, and able to sustain the pangs of hunger, is evidently considered worthy of praise by the Indian; but foremost of all is wealth.

It is considered the duty of every man to have pity upon the poor and hungry. Women are honoured for their chastity and for being true to their husbands; children, for taking care of their parents; men, for skill and daring in hunting, and for bravery in war.

Closely connected with their vanity is their inclination to flatter the stranger or friend, but particularly anyone who is expected to be of service to the Indian. Vanity and servility are the most unamiable traits of his character. Wit and humour are little appreciated, although they are not wanting. The character of the Indian, on the whole, is sombre, and he is not given to gentle emotions. Even his festivals have this character, as he retains his dignity throughout.

Food—Hunting and Fishing—Clothing—Implements.

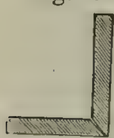
It is not the object of this report to give a full description of the various kinds of food and of the methods of hunting and fishing. It seems, however, desirable to mention the most important points in connection with this subject.

The principal part of the food of the natives is derived from the sea. It seems that whales are pursued only exceptionally, though the West Vancouver tribes are great whalers. Sea-lions and seals are harpooned, the barbed harpoon-point being either attached to a bladder or tied to the stem of the boat. The harpoon lines are made of cedar-bark and sinews. The meat of these sea-animals is eaten, while their intestines are used for the manufacture of bowstrings and bags. The bristles of the sea-lion are used by the Tsimshian and the neighbouring tribes for adorning dancing ornaments. Codfish and halibut are caught by means of hooks. These are attached to fish-lines made of cedar-twigs, or, what is more

frequently used, of kelp. The hook, the form of which is well known, is provided with a sinker, while the upper part is kept afloat by a bladder or by a piece of wood. The hooks are set, and after a while taken up. Cuttle-fish is extensively used for bait. The fish are either roasted near or over the fire, or boiled in baskets or wooden kettles by means of red-hot stones. Those intended for use in winter are split in strips and dried in the sun, or on frames that are placed over the fire. I did not observe such frames among the tribes south of the Snanaimuq. The most important fish, however, is the salmon,. which is caught in weirs when ascending the rivers, in fish-traps, or by means of nets dragged between two boats. Later in the season salmon are harpooned. For fishing in deep water a very long double-pointed harpoon is used. Herring and olachen are caught by means of a long rake. The latter are tried in canoes filled with water, which is heated by means of red-hot stones. The oil is kept in bottles made of dried and cleaned kelp. In winter dried halibut dipped in oil is one of the principal dishes of the tribes living on the outer coast. Fish, when caught, are carried in open-work wooden baskets. Clams and mussels are collected in a similar kind of basket. They are eaten roasted, or dried for winter use. Cuttle-fish are caught by means of long sticks; sea-eggs, in nets which are fastened to a round frame. Fish-roe, particularly that of herrings, is collected in great quantities, dried, and eaten with oil.

Sea-grass is cut in pieces and dried so as to form square cakes, which are also eaten with oil, as are all kinds of dried berries and roots. The Kwakiutl and their neighbours keep their provisions in large boxes. These are bent out of thin planks of cedar. At those places where the edges of the box are to be, a triangular strip is cut out of the plank, which is thus reduced in thickness. Then it is bent so that the sides of the triangle touch each other.

Fig. 1.



After three edges have been made, the sides of the fourth are sewed together. The bottom is either sewed or nailed to the box. The lid either overlaps the sides of the box (fitting on it as the cover on a pill-box) or moves on a kind of hinges. In the latter case it has always the following form.

Fig. 2.

The Coast Salish keep their stock of provisions on a loft, with which every house is provided.

In winter deer are hunted. Formerly bows and arrows were used for this purpose, but they have now been replaced by guns. The bow was made of yew-wood. The arrows had stone, bone, and iron points. The bow was held horizontally, the shaft of the arrow resting between the first and second fingers of the left hand, that grasps the rounded central part of the bow, while the arrow is held between the thumb and the side of the first finger. Deer are also captured by being driven into large nets made of cedar-bark, deer-sinews, or nettles. Elk are hunted in the same way. For smaller animals traps are used. Birds are shot with arrows provided with a thick wooden plug instead of a point.

Deer-skins are worked into leather and used for various purposes, principally for ropes, and formerly for clothing. The natives of this region go barelegged. The principal part of their clothing is the blanket. This is made of tanned skins, or more frequently woven of mountain-sheep wool, dog's hair, or of a mixture of both. The thread is spun on the bare leg, and by means of a stone spindle. The blanket is woven on a

solid frame. Another kind of blanket is woven of soft cedar-bark, the warp being tied across the weft. They are trimmed with fur. At the present time woollen blankets are extensively used. Men wear a shirt under the latter, while women wear a petticoat in addition. Before the introduction of woollen blankets, women used to wear an apron made of cedar-bark and a belt made of the same material. The head is covered with a water-tight hat made of roots. In rainy weather and in the canoe a water-tight cape or a poncho, both made of cedar-bark, is used. The women dress their hair in two plaits, while the men wear it comparatively short. The latter keep it back from the face by means of a strap of fur or cloth. Ear and nose ornaments are extensively used. They are made of bone and haliotis-shell.

Besides the baskets mentioned above, a variety of others are used, some made of dried seaweed, for keeping sewing-utensils; others made of cedar-bark, for storing away blankets. Still others are used for carrying the travelling outfit. They have two straps attached to them, one passing over the brow, the other over the breast, of the carrier. Water-tight baskets made of roots are used for cooking purposes and for holding water. Mats made of cedar-bark, of reed, and of rushes are used to a great extent, for covering the walls of the house, for bedding, for packing, for travelling in canoes, &c.

In olden times work in wood was extensively done by means of stone implements. Of these, only stone hammers are still used. They are either carved stones, flat on one side, and having a notch in the middle, attached to a handle by means of a leather strap, or they are similar in shape to a pestle. Trees were felled with stone axes, and split by means of wooden or horn wedges. The latter are still extensively used. In order to prevent the wooden wedge from splitting, a cedar-bark rope is firmly tied around its top. Boards are split out of trees by means of these wedges. They were planed with adzes, a considerable number of which were made of jade that was evidently found in the basin of Fraser and Lewis Rivers. Carvings were made with stone knives. Stone mortars and pestles were used for mashing berries and bark, the latter for mixing with tobacco. Paint-pots of stone, with two or more excavations, were extensively used. Pipes were made of slate or wood.

Canoes are principally made of cedar-wood. After the tree has been felled, about one-third of its thickness is removed by means of wedges, the outer side worked according to the proposed dimensions of the boat, and then the tree is hollowed by means of axes, fire, and adzes. When the sides of the canoe have almost reached the desired thickness, it is filled with water, which is heated by means of red-hot stones. Thus the wood becomes pliable, and is gradually shaped. In large canoes the gunwale is made higher by fastening a board to it. The northern tribes use the so-called 'Tsimshian canoe,' which has a high prow and a high stern. The southern tribes use the 'Chinook canoe,' which has a smaller prow, and the stern of which is straight up and down. Some other types of boats are used for the purposes of war and fishing. The boat is propelled and steered by means of paddles. In hunting there is a steersman in the stern of the canoe, while the harponeer stands in the stem. It seems that sails have been used only since the advent of the whites. They are sometimes made of mats of cedar-bark. Most of the large boats have names of their own. For fishing on rivers very narrow canoes are used, which differ somewhat in shape among the various tribes.

The Salish of the interior and the Lower Kootenay also live to a great extent upon fish. They use dug-out canoes, in which they navigate the lakes and rapid rivers. Fish are caught by means of hooks, but principally in bagnets. Deer, elk, mountain goat, big-horn sheep, and bears are hunted extensively. At the present time these tribes raise considerable numbers of horses, which are used in hunting and travelling. The upper Kootenay are principally hunters. They used to cross the mountains and hunt buffalo on the plains. The Salish dress in the blanket, in the same way as the coast tribes do; while the clothing of the Kootenay resembles that worn by the Indians of the plains. They wear moccasins, leggings, breeches, and a buckskin jacket, trimmed with metal and leather fringes. Men and women wear braids wound with brass spirals and trimmed with beads.

The art of pottery is unknown in British Columbia, and in the eastern parts of the province little carving in wood is done. Large baskets serve for cooking purposes. Stone hammers and pestles and mortars are still used throughout the Province.

I cannot give a satisfactory account of the arts and industries of the tribes of the interior, as these have been supplanted by the use of European manufactures, and old implements are scarce and difficult to obtain.

Houses.

The coast tribes live in large wooden houses. The plan of the house of the northern tribes differs somewhat from that of the Coast Salish, although the mode of construction is the same. The framework of the house consists of heavy posts, which support long beams. The walls and the roof are constructed of heavy planks. Those forming the walls rest upon strong ropes of cedar-bark connecting two poles, one of which stands inside the wall, while the other is outside. The boards overlap each other in order to prevent the rain from penetrating the house. The boards forming the roof are arranged like Chinese tiles. The rain flows off on the lower boards, as through a gutter.

The house of the northern tribes is square. It faces the sea. A platform of about two feet high and four feet wide runs all around it inside. It has a gable roof, which is supported by one or two beams resting on two pairs of heavy posts which stand in the centre of the front and of the rear of the house. The door is between the pair of posts standing near the front of the house. Three or four steps lead up to the door, which is on the platform. Very large houses have two or three platforms, and thus attain, to some extent, the shape of an amphitheatre. The houses are generally occupied by four families, each living in one corner. Small sheds are built on the platforms, all along the walls of the houses. They serve for bedrooms. Each family has its own fireplace, near which the enormous family settee, capable of holding the whole family, stands. Some of the houses of the Hēiltsuk· and Bilqula are built on posts, the floor being about eight feet above the ground. In these houses the fireplaces are made of earth and of stones. The Tsimshian, Haida, and Tlingit make a hole in the centre of the roof for a smoke-escape, while the Kwakiutl merely push aside one or two boards of the roof.

The houses of the Coast Salish and Nootka are very long, being occupied by a great many families, each of whom owns one section. The roofs are highest in the rear part of the house, and slope downward

towards the front. There is also a platform running along the walls of the houses; but while in the houses of the Kwakiutl it is made of earth, here it is carefully built of wood. All along the rear wall of the house, which is somewhat higher than the opposite, runs a loft, which is about five feet wide. It is used as a storeroom. There are no sheds serving for bedrooms, but the beds are arranged on the platforms.[1]

The houses here described are found in stationary villages. In travelling small sheds made of bark, of wood, or of branches are used.

The Salish of the interior used to live in subterranean houses, access to which was obtained from above. These were used in winter, and afforded a good shelter from the severe cold. In summer tents were used.

The Kootenay live in large lodges, the framework of which consists of converging poles. They used to be covered with buffalo hides, but now canvas is mostly used.

Social Organisation.

J. G. Frazer, in his comprehensive review of totemism, defines the totem as 'a class of material objects which a savage regards with superstitious respect, believing that there exists between himself and every member of the class an intimate and altogether special relation. As distinguished from a fetish, a totem is never an isolated individual, but always a class of objects.' Accepting this definition, I will try to outline the peculiar kind of totemism as observed in British Columbia. Among the Kootenay and Salish of the interior I did not find the slightest trace of the existence of totems.

The Tlingit, Haida, Tsimshian, and Hēiltsuk· have animal totems. The first of these have two phratries—the raven and eagle (or wolf); the Tsimshian have four totems—raven, eagle, wolf, and bear; the Hēiltsuk· three—raven, eagle, and killer (*Delphinus orca*). Animal totems in the proper sense of this term are confined to these four peoples. They are not found among the Kwākiutl, although they belong to the same linguistic stock to which the Hēiltsuk· belong. The clans of the four peoples mentioned above bear the names of their respective totems. These phratries or clans are exogamous. It must be clearly understood that the natives do not consider themselves descendants of the totem. The Tlingit, for instance, who believe in a transmigration of souls, state clearly and plainly that a man will be born again as a man, a wolf as a wolf, a raven as a raven, notwithstanding the fact that the animal and a member of its clan are considered relations. Thus the wolf gens will pray to the wolves, 'We are your relations; pray don't hurt us!' But notwithstanding this fact they will hunt wolves without hesitation. So far as I am aware, this is true of all tribes, although the opposite view has frequently been expressed. All my endeavours to obtain information regarding the supposed origin of this relation between man and animal have invariably led to the telling of a myth, in which it is stated how a certain ancestor of the clan in question obtained his totem. The character of these legends is uniform among all the peoples of this region; even further south, among the Kwākiutl and the northern tribes of the Coast Salish, who have no animal totem in the restricted sense of this term. As these legends reveal the fundamental views the natives hold in regard to

[1] See 'The Houses of the Kwākiutl Indians, British Columbia.' *Proc. U.S. National Museum*, 1888, pp. 197–213.

their totems, I shall give abstracts of some of them. The following are from the Tsimshian.

The Bear Gens.—An Indian went mountain-goat hunting. When he had reached a remote mountain range he met a black bear, who took him to his home, taught him how to catch salmon and how to build boats. Two years the man stayed with the bear; then he returned to his village. All people were afraid of him, for he looked just like a bear. One man, however, caught him and took him home. He could not speak, and could not eat anything but raw food. Then they rubbed him with magic herbs, and he was retransformed into the shape of a man. Thenceforth, when he was in want, he went into the woods, and his friend the bear helped him. In winter, when the rivers were frozen, he caught plenty of salmon. He built a house, and painted the bear on the front of it. His sister made a dancing-blanket, the design of which represented a bear. Therefore the descendants of his sister use the bear for their crest.

The Whale Gens.—TsErEmsā′aks went out fishing. After he had been out three days without having caught a single fish, he cast anchor at the base of a steep hill. His anchor fell upon the house of the whale, who drew the boat to the bottom of the sea. Two years he remained with the whale, who taught him his dance, and gave him the ornaments of his house. When TsErEmsā′aks returned he was grown all over with seaweed. The time which he had stayed at the bottom of the sea had seemed to him two days, but he had been there two years. He built a house, and painted the whale upon its front. He also used the mask and the blanket of the whale when dancing. Since that time the descendants of his sisters use this design.

There is another tale belonging to the Raven Gens of the Tsimshian: Yaqagwonō′osk was the descendant of a man who had been taken to the bottom of the ocean like TsErEmsā′aks. He was a great chief, and once invited all chiefs of the whole earth to a great feast, which was to be celebrated at Nass River. All the monsters of the whole coast came, using whales (*Delphinus orca*) for their boats. They were so numerous that the river was full of them. They landed and entered Yaqagwonō′osk's house. Whenever one of them opened the door water flowed into the house. Each wore his peculiar clothing. The first to enter was Kuwâ′k (this and the following names are those of dangerous points and of rapids). He was followed by Tlkwats'a′q, KntEpwē′n, Ktlkuo′l, Spaed'ana′kt, Kspaha′watlk. These last were very dangerous, and used to kill everyone passing their houses. The most dangerous monsters were seated in the rear of the house, the others around the platform nearer the door. The next to enter was Lak·anpEtsē′qtl. He wore a head-ring, which was made of twigs that passers-by used to give him in order to secure his good-will. Then came WulnEbālg·ātlso′ks and WudE'ano′n (=great hands). Yaqagwonō′osk gave everyone what he liked best: fat, tobacco, red paint, and eagle-down. All present promised to abstain henceforth from killing people, and after their return removed from the track of the canoes plying between the villages. Yaqagwonō′osk imitated the dresses of all his guests, and since that time he used them. His descendants, therefore, have all the sea-monsters on their heraldic columns.

These legends, of which I have given a few examples, do not belong to the whole gens, but to a subdivision of the same. Only the descendants in the female line of the ancestor who had an adventure of the kind

described—that is, his nephews and nieces, and their descendants in the female line—use the emblems he obtained in consequence of his adventure. This accounts for the diversity of emblems and the variety of their grouping on the carvings, paintings, and tattooings of the Indians. In these cases the whole group would therefore more properly be styled phratry than gens. The raven and wolf (eagle) groups of the Tlingit and Haida are pre-eminently phratries. Each gens, which forms a subdivision of the phratries, derives its origin from one of these mythical ancestors who had an encounter with one of the animals of the phratry.

The following is a partial list of the totems of each of the two phratries of the Tlingit:—

I. Raven: Raven, frog, goose, sea-lion, owl, salmon, beaver, codfish (wēq), skate.

II. Wolf (eagle): Wolf, bear, eagle, *Delphinus orca*, shark, auk, gull, sparrow-hawk (g'anō'k), thunder-bird.

Among this and all other tribes of the coast the crest of a group includes those animals which serve as the food of the animal from which the group takes its name.

As an example I enumerate the gentes of the Stikin tribe of the Tlingit, the only one with members of whom I came into closer contact. I give also the chief emblems of each gens:—

I. Wolf: Nanaā'ri *or* siknaq'a'dē, *bear* (corresponds to the Kagontā'n of other Tlingit tribes).
Qōk·ē'dē, *Delphinus orca*.

II. Raven: K·asq'aguē'dē, *raven*.
Kyiks'a'dē, *frog*.
K·atc'a'dē, *raven*.
Tīr hit tān (=*bark house gens*), *beaver*.
Dētlk·oē'dē (=*people of the point*), *raven*.
K·agan hit tan (=*sun house gens*), *raven*.
Qētlk·oan, *beaver*.

Among these the gens Nanaā'ri has six houses, the people of each forming a sub-gens:—

1. Harā'c hit tan, *porch house gens*.
2. Tos hit tan, *shark house gens*.
3. K·'ētgō hit tan,
4. Qūts hit tan, *bear house gens*.

The names of the remaining two houses I did not learn.

The proper names of members of the various gentes are derived from their respective totems, each gens having its peculiar names. The connection between name and totem is sometimes not very clear, but it always exists. Here are a few examples taken from gentes of the Stikin tribe:—

Nanaā'ri names:

Male: Tl'uck'ᴇ', ugly (danger face), referring to the bear.
G·aqē', crying man (referring to the howling wolf).
Sēktutlqētl, scared of his voice (to wit, the wolf's).
Ank·aqu'ts, bear in snow.

Female: Qutc gya′s, standing bear.
Hē′lEng djat, thunder-woman.
Kun djat, whale-woman.

Qōk·ē′dē names:

Cak·ā′ts, head-stick (reference doubtful).
Gōuq narū′, slave's dead body (reference doubtful).

Dētlk·oēdē names:

Yētl rEdē′, little raven.
Tlē′neqk, one alone (the raven on the beach).
Hiqtc tlē′n, great frog.
Yētl k·u djat, raven's wife.

The social organisation of the Haida is very much like that of the Tlingit. They have also two phratries, raven and eagle. Their totems are also similar to those of the Tlingit, but they are differently arranged. The most important difference is that the raven is an emblem of the eagle gens.

I. Eagle phratry (Gyītena′): Eagle, raven, frog, beaver, shark, moon, duck, codfish (l'ā′ma), waski (fabulous whale with five dorsal fins), whale, owl.
II. Raven phratry (K·'oa′la): Wolf, bear, *Delphinus orca*, skate, mountain-goat, sea-lion, ts'E′maōs (a sea-monster), moon, sun, rainbow, thunder-bird.

From some indications I conclude that the division of emblems between the two phratries is not the same among the Kaigani and the tribes of Queen Charlotte Islands, but the subject requires further study.

The phratries of the Haida are divided into gentes in the same way as those of the Tlingit. They also take their names, in the majority of cases, from their houses. The people of Skidegate village (Tlk·agitl), for instance, are divided into the following gentes:—

I. Eagle phratry: Nā yū′ans qā′etqa, large house people.
Na s'ā′yas qā′etqa, old house people.
Dj′āaquīg′it 'ena′i,
Gyitingīts 'ats,
II. Raven phratry: Naēku′n k·ēraunā′i, those born in Naēku′n.
Djāaqui′sk·uatl'adagāi (extinct).
Tlqaiu lā′nas,
K·āstak·ē′rauā′i, those born in Skidegate Street.

The following gentes are said to exist in one of the Kaigani villages. I did not learn the gentes of the eagle phratry.

I. Ts'ātl lā′nas, eagle.
II. Yak' lā′nas=middle town. Raven.
Yatl nas :had'ā′i[1]=raven house people.
k·'at nas :had'ā′i=shark house people.
gutgunē′st nas :had'ā′i=owl house people.

[1] *:h* of the Kaigani dialect stands for *q* of the other dialects. It is an *h* preceded by a slight intonation.

qō'utc nas :had'ā'i=bear house people.
na k·'āl nas :had'ā'i=empty house people.
t'ā'rō nas :had'ā'i=copper house people.
kun nas :had'ā'i=whale house people.
g·ᴇgihē't nas :had'ā'i=land-otter house people.
k·'ēt nas :had'ā'i=sea-lion house people.
:hōt nas :had'ā'i=box house people.
k'ōk' nas :had'ā'i=snow-owl house people.

From the first of these lists it will be seen that two of these gentes are called from the locality which they formerly inhabited. Wemiaminow and Krause noted a few Tlingit gentes which were also named from the places at which their houses stood, and one name of this kind is found on the preceding list on p. 824. The majority of gentes are called from the names and emblems of their houses. If a new house is built by the chief of the gens it receives the name of the old one, the place of which it takes. These facts show that the houses must be considered communal houses of the gentes. The members of the gens are connected by ties of consanguinity, not by an imaginary relationship through the totem. The latter exists only inside the phratry. It must be borne in mind that the emblems of the gens are *only* emblems commemorative of certain events, that they do not indicate any relationship between man and emblem. This becomes particularly clear in the case of the Haida phratries, where the raven is the emblem of the eagle phratry and is not used by the raven phratry. Gentes of great numerical strength are subdivided. The houses of each gens always stand grouped together.

The single gentes do not possess the whole series of emblems pertaining to the phratry. Among the Skidegate gentes enumerated above, the one called Nā s'ā'yas has the following emblems: raven, shark, eagle, frog. Their chief has, in addition to these, the fabulous five-finned whale *wask·* and the fish *l'ā'ma* (codfish ?). Before giving a festival the child of the eagle gens must use no other emblem but the eagle.

Any Haida who has the raven among his emblems, when marrying a Tlingit, is considered a member of the raven phratry, and *vice versâ*, the emblems always deciding to which phratry an individual is to be reckoned.

The social organisation of the Tsimshian is somewhat different from that of the preceding group of peoples. They have four gentes: the raven, called K·anha'da; the eagle, Laqskī'yek (=on the eagle); the wolf, Laqkyebō' (=on the wolf); and the bear, Gyīspōtuwᴇ'da. The following is a partial list of their emblems.

1. K·anha'da: Raven, codfish, starfish.
2. Laqskī'yek: Eagle, halibut, beaver, whale.
3. Laqkyebō': Wolf, crane, grizzly bear.
4. Gyīspōtuwᴇ'da: *Delphinus orca*, sun, moon, stars, rainbow, grouse, tsᴇm'aks (a sea-monster).

The Tsimshian are divided into three classes: common people, middle-class people, and chiefs. Common people are those who have not been initiated into a secret society (v. p. 848); by the initiation they become middle-class people; but they can never become chiefs, who form a distinct class. Each gens has its own proper names, which are different for chiefs and middle-class people. It seems that, as a rule, the names

are common to all tribes, with the exception of a few chiefs' names, which will be noted later on. These names are different, according to the gens to which the father belongs, and have always a reference to the father's crest. Here are a few instances :—

K·anha′da names.

1. A K·anha′da woman marries a Laqskī′yek man.

Middle-class names :—

Male : Nēesyūlâ′ops=grandfather carrying stones.
Female : Laqtlpō′n=on a whale.

Chiefs' names :—

Male : Nēeswoksenā′tlk=grandfather of the not-breathing one.
Female : Ndsē′edsd'a′loks=grandmother of ?
Ndsē′ets lē′itlks=watching's grandmother.
Līd'amloqdā′u=(eagle) sitting on the ice.

2. A K·anha′da woman marries a Gyīspotuwᴇ′da man.

Name of female : Nᴇbō′ht=making noise to each other (killers).
Names of male : Wud'adā′u=large icebergs (floating at Kuwâ′k).
Wīha′=great wind.

Laqskī′yek names.

1. A Laqskī′yek woman marries a K·anha′da man.
Male : Wonlō′otk (raven)=having no nest.

2. A Laqskī′yek woman marries a Laqkyebō′ man.
Female : Dᴇmdēmâ′ksk=wishing to be white.

3. A Laqskī′yek woman marries a Gyi′spōtuwᴇ′da man.

Names of females : Wībō′=great noise (of killers).
Wīnē′eq=great fin (of killer).
Names of males : Qpi′yēlek=half-hairy sea-monster (abbreviated from Qpī litl hag'ulō′oq).
Hats'ᴇksnē′eq=dreadful fin (of killer).

Laqkyebō′ names.

1. A Laqkyebō woman marries a Laqskī′yek man.

Chief's daughter's name : Saraitqag·ā′i=eagle having one colour of wings.

Gyīspotuwᴇ′da names.

1. A Gyispotuwᴇ′da woman marries a K·anha′da man.

Female : Bā′yuk (raven)=flying in front of the house early in the morning; abbreviated from Seō′pgyibā′yuk. The eldest daughter is always given this name.

In each village the houses of members of each gens are grouped together. The phratries of the Haida correspond to the Tsimshian

gentes in such a way that raven and eagle on one side, wolf and bear on the other, are amalgamated.

The Hēiltsuk· of Milbank Sound are also in the maternal stage, and are divided into clans having animal totems. There are three of them :—

1. K·ōiнtēnoq (=raven people), raven, starfish, sun, g·og·amā'tsē (box in which the sun was kept before the raven liberated it). Their house is painted all black.

2. Wīk'oak·нtēnoq (=eagle people). Thunder-bird (K·ani'sltsua), an enormous dancing-hat.

3. Ha'lq'aiнtēnoq (=killer people). *Delphinus orca*, K·omō'k·oa. A huge mouth is painted on the house-front, the posts are killers, two fish named MEʟнani'gun are painted at both sides of the door. Sea-lions (which are considered the dog of K·ōmō'k·oa) are the crossbeams.

The most southern tribe which belongs to this group are the Awiky'ē'noq of Rivers Inlet. Further south, and among the Bilqula, patriarchate prevails. The social organisation of these tribes differs fundamentally from that of the northern group. We do not find a single clan that has, properly speaking, an animal for its totem ; neither do the clans take their names from their crest, nor are there phratries. It seems as though the members of each gens were really kindred. The 'first' of each gens is said to have been sent by the deity, or to have risen from the depth of the ocean or the earth to a certain place which became his home.

I shall give abstracts of a few of these legends, which will explain the character of the clans of the Kwākiutl.

Hē'likilikila and Lōtlemāk·a.—Hē'likilikila descended from heaven in the shape of a bird carrying a neck-ring of red cedar-bark.[1] He built a house and made a large fire. Then a woman called Lōtlemāk·a rose from under the earth. He spoke to her: 'You shall stay with me and be my sister.' Thenceforth they lived in opposite corners of the house. The Kwats'ē'nok· had heard of Hē'likilikila's neck-ring, and made a futile attempt to steal it. When one of them entered the house where Hē'likilikila was sleeping, he was stricken with madness. Hē'likilikila, however, cured him, gave him the ring, and the Kwats'ē'nok· returned home. Since that day they dance the Tsētsā'ēk·a, in which rings of red cedar-bark are used.

Lē'laqa.—Two eagles and their young descended from heaven and alighted at Qu'mqatē (Cape Scott). They took off their eagle-skins and became men. The father's name was Nā'laqōtau; that of the mother Ank·â'layuk·oa; and the young was called Lē'laqa. One day the latter pursued a seal, which, when far away from the coast, was transformed into a cuttle-fish, and drowned Lē'laqa. After a while he awoke to new life, and flew to heaven in the shape of an eagle. Then he returned to his parents, who had mourned for him, for they believed him to be dead. They saw an eagle descending from heaven. In his talons he carried a little box, in which he had many whistles imitating the voice of the eagle. He wore the double mask Naqnakyak·umtl and a neck-ring of red cedar bark. He became the ancestor of the gens NEe'ntsa.

SE'ntlaē.—SE'ntlaē, the sun, descended in the shape of a bird from heaven, assumed the shape of a man, and built a house in Yik·'ā'men. Then he wandered to K·ō'moks, visited the Tlau'itsis, the NEmk·ic, and

[1] It conveys the secrets of the winter dance (see p. 851).

Nā′k·oartok·, and finally reached Tliksī′uaē (=the plain at the mouth of the river, where clover-root is found), in the country of the Kwākiutl, where he settled at K·′aioq. He took a wife among each tribe whom he visited, and his family has the name Sisintlē. He resolved to stay in Tliksī′uaē, and took a Kwākiutl woman for his wife. They had a son, whom they called Tsqtsqâ′lis. On each side of the door of their house they painted a large sun. The posts are men, each carrying a sun. They are called Lēla′qt'otpes, and were SE′ntlaē's slaves. The crossbars resting upon the posts also represent men, while the beams are sea-lions. The steps leading to the house-door are three men called Tlē′nonis. During the winter dances the Sisintlē use the mask of the sun, Tlē′selak·umtl; in the dance Yā′wiqa, that of the dog Ku′loqsâ (=the sun shining red through the clouds), who descended with SE′ntlaē from heaven. Their heraldic column is called SEntlē′qēm. It represents a series of copper plates, on the top of which a man called Lāqt'otpes (singular of Lēla′qt'otpes=he who gives presents to strangers only) is standing. Above all is the mask of the sun emitting rays.

Of special importance is the connection of the ancestors of these gentes with K·ā′nikilak· (meaning doubtful), the son of the deity. He is the ancestor of a gens of the Nak·o′mkilisila, who, upon the strength of this legend, claim a superiority to all others. This point seems of sufficient importance to be given in greater detail. I was told that in the far west there lived a chief called Ha′nitsum (the possessor of arrows), who had a daughter called AiHtsuma′letlilok· (with many earrings of haliotis shells). K·ā′nikilak· went into his boat K·ok·ō′malis, and after long wandering he reached Hā′nitsum's house. He married the latter's daughter, and took her home to Koā′nē (near Cape Scott). They had a son, who received the name of Hā′neus. He lived to be a great chief.

K·anikilak· wandered all over the world. In his wanderings he encountered the ancestors of all gentes of the various Kwākiutl tribes, made friends with them, and filled the rivers of their countries with salmon. I give an example of this kind of tradition. K·anikilak· met Nōmas, the ancestor of the Tlauitsis. He was the first to make fish-lines of kelp to catch halibut; therefore the Tlauitsis were the first tribe to use these. K·anikilak· made friends with Nōmas, and filled the rivers of his country with salmon. He met Ō′meātl, who was sitting on an island. When the latter saw K·anikilak· approaching, he pointed his first finger towards him, which perforated K·anikilak·'s head. Then the latter perforated Ōmeatl's head in the same way. Now they knew that they were equally strong, and parted.

In some cases it is very difficult to decide whether a group of men deriving their origin from one of these ancestors is really a gens or a tribe, particularly in those cases in which the tribal name agrees with that of the ancestor of one of the gentes; for instance, Ma′malēlēk·ala (collective of Mālēlēk·ala), or Wē′wēk·aē (collective of Wē′k·aē). A considerable number of tribal names and the majority of names of gentes are simply the collective form of the name of the ancestor. Others are taken from the regions inhabited by the tribe.

It appears that a tribe of the Kwākiutl must be defined as a series of gentes, whose ancestors first made their appearance in a certain well-defined region. Thus the ancestors of the Nak·o′mkilisila gentes appeared on or near Cape Scott; those of the Tlatlasik·oala on or near Hope Island,

of the Kwākiutl in Hardy Bay. No other connection between the several gentes seems to exist. We shall see later on that the Coast Salish have the same organisation, with the exception that the gentes are named on a different principle. The latter, however, have only very slight indications of crests, while the crests play an exceedingly important part in the life of the Kwākiutl.

In order to make clear the organisation of these tribes, I will enumerate the divisions and gentes of one group of tribes.

The following four tribes which inhabit the north-eastern part of Vancouver Island form one group I enumerate the tribes, subdivisions, and gentes of this group according to their rank.

1. Kwā'kiutl, called by the Bilqula and Coast Salish, Kwakō'otl; Fort Rupert.

Subdivisions: 1. Kuē'tEla, so called by the tribes north of Vancouver Island.
Gentes: 1, Māa'mtakyila. 2, Kwōkwā'kum. 3, Gyē'qsEm. 4, Lā'alaqsEnt'aiō. 5, Sī'sintlaē.
2. K·'ō'mōyue (=rich people). War name: Kuē'qa (=murderers).
Gentes: 1, Kwōkwā'kum. 2, Hā'anatlinō. 3, Yaai'HAk·Emē (=crab). 4, Hāailakyawē or Lâ'gsē. 5, Gyī'gyilk·am.
3. Walaskwakiutl=the great Kwākiutl.
Gentes: 1, Ts'Ents'EnHk·aiō. 2, Gyē'qsEm. 3, Wa'ulipōē. 4, K·'ōmkyūtis (=the rich ride).

2. Mamalēlek·a'la. East of Alert Bay.
Gentes: 1, TE'mtEmtlEts. 2, Wē'ōmask·am. 3, Wā'las. 4, Mā'malēlek·am.

3. NE'mkic, K·ā'matsin Lake and Nimkish River.
Gentes: 1, Tsētsētloa'lak'amaē. 2, TlātEl'ā'min. 3, Gyī'gyitk·am. 4, Sī'sintlaē. 5, Nē'nelky'ēnoq.

4. Tlauitsis, Cracroft and Turner Islands.
Gentes: 1, Sī'sintlaē. 2, NūnEmasEk·âlis. 3, Tlētlk·ēt. 4, Gyī'gyilk·am.

It remains to describe briefly their crests. Every gens has certain tales in which the reason for their using these crests is explained. I shall confine myself in this place to a list of crests of the tribes of Fort Rupert.

1. Māa'mtakyila: Carvings: Thunder-bird, crane, grizzly bear, raven, sun. Mask: Mā'takyila, sun.

2. Kwōkwā'kum: Ancestor, Tlā'k·oaki'la. Posts: Grizzly bear on top of crane, thunder-bird, crane, sun.

3. Gyē'qsEm: Crane on top of a man's head.

4. Lā'alaqsEnt'aiō: *Delphinus orca* with man's body.

5. SE'ntlaē: Sun.

6. Hāailikyawē: Large head-ring with raven head attached to it. Heraldic columns: Tsōnō'k·oa, grizzly bear, thunder-bird; Sī'siutl, crane, raven.

7. Kwōkwā'kum. Ancestor, Nō'lis. Dancing utensil: Bear with beaver tail. Post: Sea-lion. Heraldic column: Pole, man on top of it.

8. Hā'anatlinō. Mask: Man, on top of whom moon and eagle. Posts: Bear, thunder-bird.

9. TsEnHk·'aiō. Post: TsEnHk·'aiō (a species of eagle). Beams: Sea-lion. Post: Ts'E'nHk·'aiō. Heraldic column: A little man with a thick belly.

10. Gyē'qsEm. Heraldic column: Long pole, the base of which rests on a man, on top of which stands a crane, its beak turned downward, and a double-headed snake (Sisiutl).

This very fragmentary list shows that each gens uses certain carvings for certain purposes. The details of the carvings of their houses are prescribed by the legendary description of the house of the ancestor, and so are their masks and their heraldic columns. I would call attention to the important fact that the dancing implements and the dances themselves belong to the crest of the tribe, or, more properly speaking, to the customs and carvings to which the gens is entitled.

The distinction of what constitutes a gens and what a tribe is still more difficult among the Coast Salish. Their legends are very much like those of the Kwākiutl. They tell of fabulous ancestors who descended from heaven and built houses. From these a certain group of families, who always inhabit one village, derive their origin. They call themselves from the place at which their village stands, or which they claim as their original home. Whenever they leave their home, they take the name of their old village to the new place, although the name is generally a geographical one, taken from certain peculiarities of the locality. For instance, the name Tsimē'nes means 'where the landing is close by the house,' an epithet that was well adapted to their former village at the mouth of Cowitchin River, but not to their new home at Chimenes. Many such instances might be enumerated. Some of these gentes have certain prerogatives and certain carvings, but these are of very little importance when compared to those of the Kwākiutl, among whom they exert a ruling influence over their whole life. The Snanaimuq, for instance, have the following gentes: Tē'wEtqEn, Yē'cEqEn, K·oltsī'owotl, Qsâ'loqul, Anuē'nes. Among these only the first and the second are allowed to use masks, which have the shape of beavers, ducks, or salmon. Each gens has its own proper names.

I have so far stated only in a very general way that the northern tribes have a maternal, the southern a paternal organisation. It remains to give some more details on this important subject. One of the main facts is, that the phratries, viz. gentes of the Tlingit, Haida, Tsimshian, and Hēiltsuk·, are exogamous, not only among each tribe, but throughout the whole region. A member of the eagle gens of the Hēiltsuk·, for instance, cannot marry a member of the eagle phratry of the Tlingit. Those gentes are considered identical which have the same crest. I do not know whether any such law prevails in the case of marriages between the Kwākiutl and Hēiltsuk·, which, however, seem to be of very rare occurrence. Neither was I able to arrive at a fully satisfactory conclusion regarding the question whether marriages inside a gens of the Kwākiutl are absolutely prohibited, but I believe that such is the case. This difficulty arises from the fact that the Kwākiutl considers himself as belonging half to his mother's, half to his father's gens, while he uses the crest of his wife. I do not know of a single instance of a Kwākiutl marrying a member of his own gens. The Salish gentes, for instance those of the Sk·qō'mic, are not exogamous, but I am not quite positive whether this is true in all cases.

I do not intend in the present chapter to discuss the customs refer-

ring to birth, marriage, and death, all of which have reference to the social organisation of these tribes, and which help to gain a better understanding of this organisation. It will be sufficient to mention a few facts gleaned from these customs which have special reference to the questions under discussion.

The members of a gens are obliged to assist each other on every occasion, but particularly when heavy payments are to be made to other gentes. Instances of this kind will be found later on in the description of the proceedings at the occasion of the building of new houses and at burials. It is a very remarkable fact that the gens of the male line has to do certain services at such opportunities which are not paid by the individual but by the gens. Thus a gens is not permitted to touch the body of one of its members; the burial is to be arranged by the gens to which the deceased's father belongs. This solidarity of the gens is principally found among the northern tribes, which are in the maternal stage. Among the same tribes mothers' sisters are considered and called mothers, fathers' brothers, fathers, while there exist separate terms for mothers' brothers and fathers' sisters.

It is a noteworthy fact that the Hēiltsuk· and the Kwākiutl, who speak dialects of the same language, differ fundamentally in regard to their social organisation. I am inclined to believe that the matriarchate of the Hēiltsuk· is due to the influence of the Tsimshian, with whom they have frequently intermarried, and upon whom the Hēiltsuk· have had a considerable influence. But the marriage ceremonies of the Kwākiutl seem to show that originally matriarchate prevailed also among them. The husband always assumes, a short time after marriage, his father-in-law's name and crest, and thus becomes a member of his wife's clan. From him this crest descends upon his children; the daughters retain it, but his sons, on marrying, lose it, adopting that of their wives. Thus the descent of the crest is practically in the female line, every unmarried man having his mother's crest; but still we cannot call this state matriarchate proper, as the father is the head of the family, as he gives up his own crest for that of his wife. This law is carried so far that a chief who has no daughters marries one of his sons to another chief's son, the latter thus acquiring his crest. By this means the extinction of gentes is prevented. It seems, however, that the father's gens is not entirely given up, for the natives frequently use carvings of both gentes promiscuously, but certain parts of the father's gens, to which I shall refer presently, are excluded from this use. The following instance, which came under my personal observation, will show the customs of the Kwākiutl regarding this point. K'ōmena'kula, chief of the gens Gyī'gyilk·am, of the tribe Tlatlasik·oala, has the heraldic column of that gens, and the double-headed snake for his crest. In dances he uses the latter, but chiefly the attributes of the raven gens. His mother belonged to the gens Nūnᴇmasᴇk·âlis, of the Tlau'itsis; hence he wears the mask of that gens. He had an only daughter, who, with her husband, lived with him. She died, and her husband is the present owner of the heraldic column of the gens. The son of this daughter, at present a boy seven years of age, is the future chief of the gens.

Among the Salish there is no trace of matriarchal institutions. The child belongs to the father's gens, the eldest son inheriting his rank and name.

Closely connected with the gentes of the Kwākiutl are their secret societies, each of which has certain characteristic dancing implements. They are obtained by marriage in the same way in which the crest is obtained. There is, however, one restriction to the acquiring of the right to become a member of the secret society. The person who is to acquire it must be declared worthy by the tribe assembled in council. Not until this is done is the man allowed to marry the girl from whose father the right of being initiated is to be acquired. This is even true regarding the 'medicine men.' The emblems of these secret societies are rings of red cedar-bark, of various designs. The connection of the gentes and these institutions may be seen from the legend 'Hēlikilikila and Lōtlemak·a,' which was told on p. 825.[1]

Although a few of the tribes inhabiting the country adjoining that of the Kwākiutl have secret societies of the same character among them they are in no way connected with the gens. This fact, as well as the difference in the character of the legends of the gentes, proves that the social organisation of these groups of tribes is of entirely different origin. The southern groups derive their origin from a fabulous ancestor who is either himself the totem or to whose adventures the totem refers. The first is the case in the gens Sī′sintlaē, which derives its origin from the sun, Ts'ᴇ′nts'ᴇɴʜk·'aiō of the Walaskwakintl, which derives its origin from the eagle, and others. In the majority of cases the crest refers to adventures of the ancestor. In the northern groups we observe a pure animal totem, but the animal is not considered the ancestor of the gens bearing its name. The crest always refers to adventures of one of the ancestors.

Government and Law.

The people of this country are divided into three classes: common people, middle class, and chiefs. While the last form a group by themselves, the members of the class forming the highest nobility, children of middle-class people are born common people, and remain so until they become members of a secret society, or give a great feast and take a name. All along the coast the giving away of presents is considered a means of attaining social distinction. The chief has numerous prerogatives, although his influence upon the members of the tribe is comparatively small. I am best acquainted with his claims among the Tsimshian, but it seems probable that these institutions are much alike among the various peoples. He has to carry out the decisions of the council; more particularly, he has to declare peace and war. His opinion must be asked by the tribe in all important events. He decides when the winter village is to be left, when the fishing begins, &c. The first fish, the first berries, &c. are given to him. It is his duty to begin all dances. He must be invited to all festivities, and when the first whistles are blown in winter, indicating the beginning of the dancing season, he receives a certain tribute. People of low rank must not step up directly to a chief, whose seat is in the rear of the house, but must approach him going along the walls of the house.

The highest in rank among all Tsimshian chiefs is the one of the Gyispaqlâ′ots tribe. His name is invariably Lᴇgī′eq. He is considered

[1] See the author's paper on 'The use of masks on the North-West Coast of America,' in *Internationales Archiv für Ethnographie*, 1888.

the noblest, because a number of secret societies are only permitted to his family and tribe. This is accounted for by the fact that these secret societies were acquired by marriage from the Gyit'amā't. Tradition says——and it is undoubtedly correct—that a woman of the Gyispaqlâ'ots tribe eloped with a Gyit'amā't chief, to whose gens these dances belonged. After her return the woman was given the name G·'amdema'qtl (= only in eloping ascending mountain). The name Lᴇgī'eq is a Gyit'amā't name. It is a privilege of the Gyispaqlâots to trade with the Gyitksa'n; and they kept up this privilege successfully even against the Hudson Bay Company until the latter purchased it from them in 1886. The Gyit'ᴇndâ chiefs are relatives of those of the Gyispaqlâ'ots. They share their privileges, and bear the same names, the one Lᴇgī'eq excepted.

The Gyitqā'tla are considered higher in rank than any other of the tribes of the Tsimshian proper. They have the same secret societies which the Gyispaqlâ'ots and Git'ᴇndâ' have. They acquired them through intermarriage from the Gyitlō'p and Hēiltsuk·. Only quite recently the Haida acquired them from the Gyitqā'tla.

The Gyits'umrä'lon are not of Tsimshian origin. Six generations (that is, about 150 years) ago a number of Tongas (Tlingit), men and women, emigrated from Alaska in consequence of continued wars, and settled on the brook of Gyits'umrä'lon. They married a number of Tsimshian women and men, among whom the names Rataqä'q and Astoē'nē are mentioned. For a considerable time they continued to speak Tlingit, but finally were assimilated by the Tsimshian. Their descendants are still called Gunhō'ot (runaways).

It is becoming to a chief to be proud and to leave his memory to his descendants. Therefore the Lᴇgī'eq, who ruled 150 years ago (the sixth back), had his figure painted on a vertical precipice on Nass River. A series of coppers is standing under his figure. Since that time the place is called Wulgyilᴇgstqald'amptk (where self on written).

Seven generations ago Nēswība'sk (grandfather great wind), a chief at Meqtlak·qā'tla, had his figure carved on a rock on an island near Meqtlak·qā'tla. He lay down, had his outline marked, and the carving completed in a single night.

The Gyitg·ā'ata of Grenville Channel are subjects of the chief of the Gyitwulgyâ'ts. They have to pay a tribute of fish, oil, berries, and skins every year. The Gyitlâ'op are subjects of the chief of the Gyitqā'tla.

When a chief dies the chieftaincy devolves upon his younger brother, then upon his nephew, and, if there is none, upon his niece. Only, if a chief's family dies out the head man of his crest can become chief. This is the only case in which a middle-class man can advance to the rank of a chief. The chief's property, as well as that of others, is inherited first by the nephews; if there are none, then by the deceased's mother or aunt. A woman's property is inherited by her children.

There are very few common people, for whoever can afford it lets his child enter a secret society immediately after birth, by proxy. The child thus becomes a middle-class man. The more feasts are given by him the higher becomes his rank, but no member of the middle class can ever become a member of the chief class. The chief's daughter on reaching maturity must grind down her teeth by chewing a pebble of jade (see p. 808). So far as I know, this is the only deformation of the body which is confined to one class only.

When a family is liable to die out the father is allowed to adopt one

of his daughters, who then receives a name belonging to his crest. On this occasion a great festival is given. A man cannot adopt more than one child at a time.

The council is composed of middle-class men. Nobody who has not taken a name, or who is not a member of a secret society, is allowed to take part in it. The mother's brother represents his nephews. A woman is only admitted if she is the head of a family.

The council decides all important questions concerning the tribe, and is the court which judges criminals. Those who are found guilty of sorcery are tied up and placed at the edge of low water, and are left there to be drowned. According to legends, such people were frequently left alone in the winter village to starve to death. If a man does not observe the prescribed rules during dances he is tied and brought before the council. If nobody speaks in his favour he is killed, else he is punished by being made a slave, or by heavy payments. All crimes can be atoned for by sufficient payments. If such are not made it is the duty of the nearest relatives to take revenge.

The coast tribes have always been great traders, and they had a certain currency. Dentalia, skins, and slaves were standards of value. For less valuable property marmot-skins sewed together served as currency. The Tsimshian used to exchange olachen oil and carvings of mountain-goat horn for canoes. The Chitlk·at sold their beautiful blankets; the Heiltsuk·, canoes; while the southern tribes furnished principally slaves.

The latter were in every respect the property of their masters, who were allowed to kill them, to sell them, or to give them their liberty. Children of slaves were also slaves.

Strangers are always received kindly and with much ceremony. Among the tribes who still adhere to their old customs they are offered the host's daughter while they remain.

So far as I am aware, the institutions of the Haida, Tlingit, and Hēiltsuk· are much the same as those described here. I did not learn any details, as I did not visit these tribes in their homes.

The following observations hold good for the Kwākiutl and Coast Salish, as well as for the northern group of tribes. Polygamy is not of rare occurrence, although generally each man has only one wife. The first wife is of higher rank than those married at a later date. Women must not take part in the councils and feasts, except when they are heads of families (or, among the Kwākiutl, chief's daughters); but the husband takes home from the feast a dish of all the various kinds of food that were served. The dish must be returned the same night.

The principal work of the women is gathering berries and clams, drying fish, and preparing the meals. They weave mats, blankets, and hats. The men, on the other hand, hunt and fish, they fetch fuel—if large logs are wanted—and build houses and canoes. They also make the carvings and paintings.

The property of the whole gens is vested in the chief, who considers the salmon rivers, berry patches, and coast strips, in which the gens has the sole right, as his property. Houses belong to the man who erected the framework. They are always inhabited by members of one gens. Canoes, fishing-gear, &c. are personal property. Women own boxes, dishes, and other household goods.

The Kwākiutl.—As among these tribes paternal institutions take the place of maternal institutions, many laws are found that are not known

to the northern group of tribes. If such is possible, the rank of each man is here still more exactly fixed than among their neighbours. The rank is determined by the gens to which a man belongs, by the feasts he has given, and by the secret societies to which he belongs. In the list of gentes on page 827 I have enumerated the Kwākiutl gentes according to their social standing. In great festivals celebrated for the purpose of acquiring rank by giving away property, the noblest guests sit in the rear part of the house, nearest the fire, and the lower in rank the farther back they sit. When only one row is formed those lowest in rank sit nearest the door.

The affairs of the whole tribe are discussed in council, in which only men participate. Before the opening of the discussion four songs are sung and four courses are served. Then the public affairs are discussed in long and elaborate speeches, delivered principally by the chiefs. In time of peace there is no chief who has acknowledged authority over the whole tribe, but each gens has its own chief. A certain superiority of social standing is acknowledged in those who have given a great donation feast. In times of war a war chief is elected.

The chief represents his gens, and carries out the decision of the council. Except on delivering speeches, he does not speak to people of low rank, but converses with them through messengers.

If a single person is offended, the gentes of both his father and mother are obliged to come to his help. Thus the long war between the Coast Salish and Lekwiltok originated. Formerly these wars were of so frequent occurrence that the villages all along the coast were protected by stockades.

The institutions of the Coast Salish and of the Kwākiutl are pretty much the same, except that the former have a pure patriarchate, and the child inherits his father's rank and property.

Among the Sk·qō′mic, for instance, the chieftaincy devolves upon the chief's son. If there is only a daughter his grandson is the successor. If there are no children a new chief is elected from among his gens. If the successor is a young boy a representative is elected who acts as chief until the boy is grown up and has assumed a name. If a man dies his wife inherits all the property and keeps it until her children are grown up. After the death of the husband she gives a potlatch to his memory.

Among all the tribes heretofore described each gens owns a certain district and certain fishing privileges. Among the Tlingit, Haida, and Tsimshian each gens in each village has its own fishing-ground; its mountains and valleys, on which it has the sole right of hunting and picking berries; its rivers in which to fish salmon, and its house-sites. For this reason the houses of one gens are always grouped together. I do not know of any tradition which accounts for this fact, or of any other foundation of their claim. The Kwākiutl, who have the same distribution of land among the various gentes, account for this fact by saying that the ancestor of each gens descended from heaven to the particular region now owned by his descendants. Later on K·anikilak·, the son of the deity (see p. 826), in his wanderings encountered these ancestors, and gave them the country they inhabited as their property, filling at the same time their rivers with salmon. The Coast Salish derive their claims to certain tracts of land in the same way from the fact that the ancestor of each gens came down to a certain place, or that he settled there after the great flood. The right of a gens to the place where it

originated cannot be destroyed. It may acquire by war or by other events territory originally belonging to foreign tribes, and leave its home to be taken up by others; the right of fishing, hunting, and gathering berries in their old home is rigidly maintained. A careful study shows that nowhere the tribe as a body politic owns a district, but that each gens has its proper hunting and fishing grounds, upon which neither members of other tribes nor of other gentes must intrude except by special permission. It would be an interesting and important object of study to inquire into the territorial rights of each gens, for such a study would undoubtedly throw much light upon the ancient history of these peoples. These rigid laws in regard to the holding of land by the gentes are very important in the past history of the Indians of British Columbia, and are of prime importance in their present relations to the white settlers.

One of the most complicated and interesting institutions of these tribes is the so-called *potlatch*—the custom of paying debts and of acquiring distinction by means of giving a great feast and making presents to all guests. It is somewhat difficult to understand the meaning of the potlatch. I should compare its most simple form to our custom of invitation or making presents and the obligations arising from the offering, not from the acceptance, of such invitations and presents. Indeed, the system is almost exactly analogous, with the sole exception that the Indian is more anxious to outdo the first giver than the civilised European, who, however, has the same tendency, and that what is custom with us is law to the Indian. Thus by continued potlatches each man becomes necessarily the debtor of the other. According to Indian ideas any moral or material harm done to a man can be made good by an adequate potlatch. Thus if a man was ridiculed by another he gives away a number of blankets to his friends, and thus regains his former standing. I remember, for instance, that the grandson of a chief in Hope Island by unskilful management of his little canoe was upset near the beach and had to wade ashore. The grandfather felt ashamed on account of the boy's accident, and gave away blankets to take away the occasion of remarks on this subject In the same way a man who feels injured by another will destroy a certain amount of property; then his adversary is compelled to do the same, else a stain of dishonour would rest upon him. This custom may be compared to a case when a member of civilised society gives away to no good purpose a considerable amount of money ostentatiously in order to show his superiority over a detested neighbour. I adduce these comparisons to show that the custom is not so difficult to understand, and is founded on psychical causes as active in our civilised society as among the barbarous natives of British Columbia. A remarkable feature of the potlatch is the custom of giving feasts going beyond the host's means. The procedure at such occasions is also exactly regulated. The foundation of this custom is the solidarity of the individual and the gens, or even the tribe, to which he belongs. If an individual gains social distinction his gens participates in it. If he loses in respect the stain rests also on the gens. Therefore the gens contributes to the payments to be made at a festival. If the feast is given to foreign tribes the whole tribe contributes to these payments. The method by which this is done has been well set forth by Dr. G. M. Dawson ('Trans. Roy. Soc. Can.' 1887, page 80). The man who intends to give the potlatch first borrows as many blankets as he needs

from both his friends and from those whom he is going to invite to the feast. Everyone lends him as many as he can afford, i.e. according to his rank. At the feast these are given away, each man receiving the more the higher his rank is. All those who have received anything at the potlatch have to repay the double amount at a later day, and this is used to repay those who lent blankets. At each such feast the man who gives it acquires a new and more honourable name.

Among the Snanaimuq I observed the following customs: The chief's son adopts, some time after his father's death, the latter's name. For this purpose he invites all the neighbouring tribes to a potlatch. The Snanaimuq have a permanent scaffold erected in front of their houses, on which the chief stands during the potlatch, assisted by two slaves, who distribute the presents he gives away among his guests, who stand and sit in the street. As it is necessary to give a great festival at the assumption of the chief's name, the new chief continues sometimes for years and years to accumulate wealth for the purpose of celebrating this event. At the festival his father's name is given him by four chiefs of foreign tribes.

I will give here some details on the wars of this tribe. The warriors were thoroughly trained. They were not allowed to eat while on the war-path. Before setting out on such an expedition they painted their faces red. When near the village they intended to attack, the party divided one half hid in the woods behind the village, while the others watched in their canoes. When the latter gave a sign both parties attacked the village. When successful, the men were killed, the women and children carried off as slaves. The heads of the slain were cut off, taken home, and planted on poles in front of the houses.

It may be of interest to hear the history of one of these wars that raged for many years about the middle of this century as told by a chief of the Snanaimuq. K·oä'ᴇlite, a chief of the Sī'ciatl, had a daughter, who was the wife of a chief of the Snanaimuq. Once upon a time the former tribe was attacked by the Lē'kwiltok·, and many men had been killed. Then Koä'ᴇlite sent to the chief of the Snanaimuq and called upon him for help. They set out jointly and met the Lē'kwiltok· at Qu'sam (Salmon River). In the ensuing struggle the Sī'ciatl and Snanaimuq were victorious, but many of their warriors were killed. They brought home many heads of their enemies. The friends of the Snanaimuq, however, were sad when they heard of the death of so many of their friends, and they resolved to take revenge. They all, the Pēnā'leqats, T'ä'tᴇkᴇ, Yeqo'laos, Qelä'ltq, Çᴇk·ᴇmē'n, Snōnō'os, Snanaimuq, and Sī'ciatl, gathered and made war upon the Lē'kwiltok·. Another battle was fought at Qu'sam, in which the Lē'kwiltok· were utterly defeated, and in which many slaves were captured. Now the Lē'kwiltok· called upon their northern neighbours for help. They were greatly reduced in numbers; of the Tlaa'luis only three were left. Then these tribes went south to take revenge, and in a number of battles fought with the southern tribes, who had meanwhile been joined by the tribes of Puget Sound. While the war was thus raging with alternating success, part of the tribes on Vancouver Island had removed to the upper part of Cowitchin River, others to Nanaimo River, still others to the mainland. Posts were continually maintained to keep the tribes informed of movements of the Lē'kwiltok· and their allies. Once they had unexpectedly made an expedition southward before the tribes were able to gather. They had gone past Fraser River to Puget Sound and had massacred the tribes of that region.

Meanwhile those assembled on Cowitchin River had sent word to the tribes of Fraser River and summoned them to come to the island. They told them to pass through Cowitchin Gap and to look on the shallow beach on the north side of that channel for a signal. They obeyed. Meanwhile all the tribes on the island had assembled and determined to await the return of the Lē'kwiltok· in Maple Bay. To indicate this they erected a pole, sprinkled with the blood of a blue jay, at the beach in Cowitchin Gap, and made it point towards Maple Bay. Thus they all assembled. Early one morning they heard the Lē'kwiltok· coming. They sang songs of victory. Unexpectedly they were attacked. Almost all of them were slaughtered, their canoes sunk, and women and children enslaved. A few reached the shore, but were starved near Comox. This was the last great battle of the war. The narrator's father made peace with the northern tribes. He was the first to settle again on Gabriola Island. He emancipated his slaves. When peace was made the chiefs made their peoples intermarry.

I have no observations to offer on the government or laws of the Kutona'qa, except that usually the chief is succeeded by his son. If the latter is not considered worthy the new chief is elected from among his family.

Customs regarding Birth, Marriage, and Death.

Krause gives the following reports of the customs of the Tlingit observed at the birth of a child. He says that, according to Kemiaminow, the women are assisted by midwives. After the child is born the young mother has to remain for ten days in a small hut, which is erected for this purpose, and in which the child was born. The new-born infant is washed with cold fresh water and kept in a cradle filled with moss. It is not given the breast until all the contents of its stomach (which are considered the cause of disease) are removed by vomiting, which is promoted by pressing the stomach. A month after birth the mother is said to leave her hut for the first time; then she washes her child and puts on new clothing. For five days after birth the mother does not partake of any food, but drinks a little lukewarm water.

Among the Tsimshian I observed the following customs: A woman who is with child is not allowed to eat tails of salmon, as else the confinement would be hard. She must rise early in the morning and leave the house before any of the other inhabitants leave it. Before the child is born the father must stay outside his house, and must wear ragged clothing. After the child is born he must abstain from eating any fat food, particularly porcupine, seal, and whale. The mother is confined in a small house or in a separate room.

Numerous ceremonies must be observed when girls reach maturity. When about thirteen or fourteen years old they begin to practise fasting, eating in the afternoon only, as a very severe fasting is prescribed at the time when they reach maturity. It is believed that if they had any food in their stomachs at this time they would have bad luck in all future. They must remain alone and unseen in their room or in a porch for ten days, and abstain from food and drink. For four days they are not even allowed a drop of water. For a fortnight the girl is not permitted to chew her own food. If she desires to have two or three boys when married, two or three men chew her food for her; in the other case, two or three

women. At the end of this fasting they are covered with mats and held over a fire. It is believed that by this ceremony her children are made to be healthy; if it were omitted they would die, even if they grow up to be a few years old. The girl is not allowed to look at fresh salmon and olachen for a whole year, and has to abstain from eating it. Her head is always covered with a small mat, and she must not look at men. She must not lie down, but always sit, propped up between boxes and mats. Her mother's clan give a great feast and many presents to her father's clan. At this feast her ears are perforated, and she is given ear-ornaments. When a chief's daughter reaches maturity she is given a jade pebble, which she must bite until her teeth are completely worn down in the middle. When the festival was held slaves were often given away or killed.

I will mention in this place that women when drinking for the first time after marriage must turn their cup four times in the same direction in which the sun is moving, and drink very little only. The perforation of the ears is repeated at later occasions, and every time a new hole is made a new festival is celebrated.

After a death has occurred, the relatives of the deceased have their hair cut short and their faces blackened. They cover their heads with ragged and soiled mats, and go four times around the body singing mourning songs. They must speak but little, confining themselves to answering questions, as it is believed that they would else become chatterboxes. Until the body is buried they must fast, eating only a very little at night. Women of the gentes to which the deceased did not belong act as wailers, and are paid for their work, the whole gens of the deceased contributing to the payment. In wailing the women must keep their eyes closed. The gens to which the deceased person's father belongs must bury him. The body lies in state for a number of days. It is washed immediately after death, placed upright and painted with the crest of the gens of the dead person. His dancing ornaments and weapons are placed by his side. Then the body is put into a box which is tied up with lines made of elk-skins. These are furnished by the gens of the deceased, and kept as a payment by the other gens. The bodies, except those of shamans, are burnt. The box is placed on the funeral pile, the lines of elk-skin are taken off and kept by the father's gens. A hole is cut into the bottom of the box and the pile is lighted. Before all is burnt the heart is taken out of the body and buried. It is believed that if it were burnt, all relations of the deceased would die. The father's gens, besides receiving the lines, is paid with marmot-skins and blankets. The nearest relations mourn for a whole year. Some time after the burial a memorial post is erected and a memorial festival celebrated. If many members of one family die in quick succession, the survivors lay their fourth fingers on the edge of the box in which the corpse is deposited and cut off the first joint 'to cut off the deaths' (gyidig'ots). The bodies of shamans are buried in caves or in the woods. These customs are common to the Tlingit, Haida, and Tsimshian.

Bilqula.—Among the Bilqula I noted the following customs: They have professional midwives to assist the woman, who is delivered in a small house built for this purpose. The child is washed in warm water. The mother must remain for ten days in her room. Father and mother are not allowed to go near the river for a year, else the salmon would take offence.

Girls when reaching maturity must stay in their bedroom, where they have a fireplace of their own. They are not allowed to descend to the floor, and do not sit by the fire of the family. After a while they may leave their room, but only through a hole cut in the floor (the houses standing on piles), through which they must also enter. They are allowed to pick berries, but for a whole year they must not come near the river or the sea. They must not drink more than is absolutely necessary. They must not eat salmon of the season, else they would lose their senses, or their mouths would be transformed into long beaks. They must not eat snow, which is much liked by the Indians, nor must they chew gum.

Kwākiutl.—There are the same restrictions regarding the place in which women are confined and regarding the food of girls reaching maturity. The marriage customs are of peculiar interest on account of the transition from maternal to paternal institutions that may be observed here. If a young man wishes to marry a girl, he must send messengers to the girl's father and ask his permission. If the father accepts the suitor, he may demand fifty or more blankets, according to his rank, to be paid at once. He demands double that number to be paid after three months. After this second payment has been made, the young man is allowed to live with his wife in his father-in-law's house. When he goes to live there the young man gives a feast to the whole tribe, without giving away any blankets, and receives from his father-in-law fifty blankets or more. At the same time his father-in-law states when he intends to refund the rest. During the feast, in which the young wife takes part, she tells her father that her husband wishes to have his carvings and dances. Her father is obliged to give them to him, and promises to do so at a future occasion. After three months more the young man pays his father-in-law 100 blankets to gain permission to take his wife to his own home. The blankets which he has given to his father-in-law are repaid by the latter with interest. At the appointed time the woman's father gives a great feast to the whole tribe. He steps forward carrying his copper, the emblem of richness and power, and hands it to his son-in-law, thus giving him his name, carvings, and dances. The young man has to give blankets to every guest attending the feast; the nobler the guest is, the more blankets he receives.

The dowry of the bride consists of bracelets made of beaver-toes and copper; so-called 'button-blankets,' copper-plates, and the gyī'serstâl. The last is a heavy board shaped like one of the lids of Indian boxes. Its front is set with sea-otter teeth. It is said to represent the human lower jaw, and I was told that it indicates the right of the husband to command his wife to speak or to be silent as he may desire.

The bride receives her boxes and other household goods from her parents. After the marriage she makes presents of dishes, spoons, trays, and similar objects to the whole tribe in behalf of her husband, in order to show his liberality. If the woman should intend to separate from her husband, and to return to her parents, her father must repay twofold all he has received from his son-in-law. If there should be a child, he has to repay him threefold. This third part becomes the property of the child. Frequently this is only a sham divorce, entered into to give an opportunity to the father-in-law to show his liberality and wealth. As soon as he has paid the husband, the latter repurchases his wife. I was

told that the *gyī'serstâl* is not used by the Lē'kwiltok·. It is certainly not known to the Coast Salish.

Among the Tlatlasik·oala and Awīky'ē'nok· the gens of the young man go out to meet his bride. They connect four boats by long boards and perform a dance on this platform. The dance is called *Ia'tiati* by the Tlatlasik·oala. Among the Awīky'ē'nok another dance is performed, in which a woman has the chief part. She carries a carved piece of wood about a foot and a half long, of the shape shown by the figure, and set with haliotis shells. Besides her, four masked dancers take part in the dance. They are called Wīnoquē'lak·, Yaiauā'lak·amē, Aiqumā'lakila, and Yaiawinō'akila. Unfortunately I was unable to understand the meaning of their dance.

Fig. 3.

The dead are put into boxes and buried either in a separate burial ground or deposited in the higher branches of trees. The tribes living at the northern end of Vancouver Island have separate burial grounds for chiefs and for common or middle-class people. The box containing the body is placed in a small house similar to those of the Tlingit and Haida. The house is covered with blankets, and strips of blanket are fastened to poles erected near the grave or to lines drawn from one tree to the other. Memorial columns, showing the crest of the tribe, are erected near the graves. Large spoons are placed alongside the houses, and are filled with food when the body is buried. At the same time food is burnt on the beach. If the body is hung up in a tree, the lower branches are carefully removed to make it inaccessible. Sometimes chiefs are buried in canoes. The Koskimo frequently bury their dead in a cave. The graveyards are generally situated on small islands or grounds near the village, and are one of the most remarkable sights on the coast, on account of the great display of colours and carvings.

The regulations referring to the mourning period are very severe. In case of the death of husband or wife, the survivor has to observe the following rules: For four days after the death the survivor must sit motionless, the knees drawn up toward the chin. On the third day all the inhabitants of the village, including children, must take a bath. On the fourth day some water is heated in a wooden kettle, and the widow or widower drips it upon his head. When he becomes tired of sitting motionless, and must move, he thinks of his enemy, stretches his legs slowly four times, and draws them up again. Then his enemy must die. During the following sixteen days he must remain on the same spot, but he may stretch out his legs. He is not allowed, however, to move his hands. Nobody must speak to him, and whosoever disobeys this command will be punished by the death of one of his relatives. Every fourth day he takes a bath. He is fed twice a day by an old woman at the time of low water, with salmon caught in the preceding year, and given to him in the dishes and spoons of the deceased. While sitting so his mind is wandering to and fro. He sees his house and his friends as though far, far away. If in his visions he sees a man near by, the latter is sure to die at no distant day; if he sees him very far away, he will continue to live long. After the sixteen days have passed, he may lie down, but not stretch out. He takes a bath every eighth day. At the end of the first month he takes off his clothing, and dresses the stump of a tree with it. After another month has passed he may sit in a corner of the house, but for four months he must not mingle with others. He must not use the

house-door, but a separate door is cut for his use. Before he leaves the house for the first time he must three times approach the door and return, then he may leave the house. After ten months his hair is cut short, and after a year the mourning is at an end. At present the Indians abstain, during the mourning, from the use of European implements.

Food is burned for the dead on the beach, sometimes in great quantities, which is intended to serve for their food. The mourners wail every morning on the beach, facing the grave. The women scratch their faces with their nails, and cut them with knives and shells.

After the chief's death a great feast is celebrated, in which the son adopts his father's name. At first mourning songs are sung, in which stones are used instead of sticks for beating time. Then the whistle Ts'ē'koityala is heard, which ends their mourning and restores happiness to their minds. After a while the chief's son enters, carrying his copper plate, and, assuming his father's name, becomes the new chief.

Coast Salish.

I am best acquainted with the customs of the Snanaimuq, which are probably almost identical with those of the other tribes of this group, the Çatlō'ltq excepted, whose customs are more alike to those of the Kwākiutl than to those of the other Coast Salish.

It is the custom of the Snanaimuq that, if a woman is to be delivered, all the women are invited to come, and to rub cedar-bark, which is used for washing and bedding the babe. Two women, the wives of chiefs, wash the new-born babe. All those who do any work on behalf of the mother or child are paid with pieces of a mountain-goat blanket. The mother must not eat anything but dried salmon, and is not allowed to go down to the river. The children are not named until they are several years old. Then all the gentes of the tribe are invited, and at the ensuing festival the child receives the name of his grandfather or that of another old member of the gens. Names once given are not changed, except when that of a chief is assumed by his son.

The man who wants to marry a girl goes into the house of her parents, and sits down, without speaking a word, close by the door. There he sits four days, without eating any food. For three days the girl's parents abuse him in every way, but on the fourth day they feign to be moved by his perseverance, and the girl's mother gives him a mat to sit on. In the evening of the fourth day the girl's parents call on the chief of the gens, and request his wife to invite the young man to sit down near the fire. Then he knows that the parents will give their consent to the marriage. A meal is cooked; some food is served to the young man, and some is sent to his parents in order to advise them of the consent of the girl's family. The latter, on receiving the food, accept it, and turn at once to cooking a meal. They fill the empty dishes in which the food was sent, and return them to the girl's parents. Then both families give jointly a great feast. The young man's parents load their boat with mountain-goat blankets and other valuable presents, and leave the landing-place of their house and land at that of the bride's house. They are accompanied by the members of their gens. Meanwhile the bride's gens has assembled in her house. The chiefs of the groom's gens deliver the presents to the bride's parents, making a long and elaborate speech. In return, the bride's parents present these chiefs

with a few blankets, which are handed to them by the chiefs of their gens. Then the groom's gens is invited to partake in a great feast. After these ceremonies are ended, the young man and his gens return to the boat, and stay for a few hours on the water. Meanwhile the bride is intrusted to the care of the highest chief of her gens, who takes her by the hand, carrying a rattle elaborately carved, of mountain-goat horn, in the other. Besides this, he carries a mat for the bride to sit on. Then the highest chief of the other gens takes her from the hands of the former, and leads her into the boat. The presents given by the parents of the young man are restored, later on, in the same proportion by the bride's parents.

While these formal ceremonies are always observed when both parties are of high rank, in other cases, if both parents are of the same rank, the marriage is sometimes celebrated only by a feast and by a payment of the value of about forty blankets to the bride's parents by those of the groom. These are also restored later on.

If the families are of different social standing, the whole gens of those parents who are of higher rank may go to the young couple and recover the husband or wife, as the case may be. This is considered a divorce. Or the chiefs of the offended gens summon a council, and the case is settled by a payment of blankets.

The following funeral customs are practised by the Snanaimuq. The face of the deceased is painted with red and black paint. The corpse is put in a box, which is placed on four posts about five feet above the ground. In rare instances only the boxes are fastened in the tops of trees, which are made inaccessible by cutting off the lower branches. Members of a gens are placed near each other, near relatives sometimes in a small house, in which the boxes are enclosed. A chief's body is put in a carved box, and the front posts supporting his coffin are carved. His mask is placed between these posts. The graves of great warriors are marked by a statue representing a warrior with a war-club. There is nothing to distinguish a shaman's grave from that of an ordinary man. The mourners must move very slowly. They are not allowed to come near the water and eat the heads of salmon. They must cook and eat alone, and not use the fire and the dishes which other people use. Every morning they go down to the beach and wail for the dead. After the death of a young child, the parents cut off their hair, but there is no other ceremony.

After the death of husband or wife, the survivor must paint his legs and his blanket red. For three or four days he must not eat anything. Then three men or women give him some food, and henceforth he is allowed to eat. Twice every day he must take a bath, in which he or she is assisted by two men or women. At the end of the mourning period the red blanket is given to an old man, who deposits it in the woods.

At the death of the chief the whole tribe mourns. Four days after the death occurred the whole tribe assembles, and all take a bath, which concludes the mourning.

Kutonaqa.—I have not obtained any information regarding customs referring to birth.

When a girl reaches maturity she must inform her mother and grandmother, who lead her to a lonely place, or the woods, and provide her with food for about twenty days. When this food is at an end, she

returns at night to the village for more. If anybody should happen to find her whereabouts, she has to resort to another secluded place. Generally she has to shift her hiding-place four times. She must abstain from certain kinds of food in order to preserve her teeth. She must not eat soup made of shavings from deer or elk skin, as else her skin would become an unclean complexion. She must not eat bones with marrow, heart, or kidney. An unmarried woman must eat neither breast nor tenderloin of any animal. If she should eat tenderloin of both sides of the animal, it is believed she would give birth to twins. Neither must she eat meat lying around the *obturator foramen* of the pelvic bone, else an enemy's arrow would hit her husband in that part.

When a young man wishes to marry a girl, he has to make a certain payment to his parents-in-law. It seems there is no further ceremony connected with the marriage. After marriage the woman's parents give some presents to the young couple. The first child is often sacrificed to the sun, to secure health and happiness to the whole family. An old 'brave' is requested to give a boy his name, to make him a good warrior. Children must not eat blood and marrow, else they will become weak.

The dead are buried in an outstretched position. The head was probably always directed eastwards. They kill the deceased's horse and hang his property to a tree under which his grave is. The body is given its best clothing. The mourners cut off their hair, which is buried with the body. When a warrior dies, they paint his face red, and bury him between trees which are peeled and then painted red.

Before the body is buried, they prophesy future events from the position of his hands. These are placed over the breast of the body, the left nearer the chin than the right. Then the body is covered with a skin, which after a few minutes is removed. If the hands have not changed their position, it indicates that no more deaths will occur in the same season. If they are partly closed, the number of closed fingers indicates the number of deaths. If the point of the thumb very nearly touches the point of the first finger, it indicates that these deaths will take place very soon. If both hands are firmly closed, they open the fingers one by one, and if they find beads (torn from the clothing ?) in the hands, they believe that they will have good fortune. If they find dried meat in the hand, it indicates that they will have plenty of food. If both hands are closed so firmly that they cannot be opened, it indicates that the tribe will be strong and healthy and free from disease. These experiments are repeated several times.

While a few men bury the body, the mourners remain in the lodge motionless. When those who have buried the body return, they take a thornbush, dip it into a kettle of water, and sprinkle the doors of all lodges. Then the bush is broken to pieces, thrown into a kettle of water, which is drunk by the mourners. This ends the mourning ceremonies.

After the death of a woman, her children must wear until the following spring rings cut out of skin around the wrists, lower and upper arms, and around the legs. It is believed that else their bones would become weak.

Religions.

Tlingit.—While the shamanistic practices and customs are very much alike among the various peoples of the North Pacific coast, their ideas about future life and the great deities deserve a separate description. The

Tlingit believe that the soul, after death, lives in a country similar to ours. Those who have died a violent death go to heaven, to a country ruled by Tahit; those who die by sickness (also women dying in child-bed) go to a country beyond the borders of the earth, but on the same level. It is said that the dead from both countries join during the daytime. I believe that this idea, which is also held by the Haida, must be ascribed to Eskimo influence. The ideas of the Tlingit regarding future life are best described in the following tales, which are told as adventures of shamans who lived about 150 or 200 years ago:

A shaman had been sick for many years. When he felt that he could not recover, and death was approaching, he asked his mother to take good care of his dog. He died. The corpse was wrapped in furs, and on the fourth day he was buried in the graveyard of the shamans, near the beach. Every day his mother went to the little house in which his body was deposited, bewailing his death, and burning food for him. One day the dog, who had accompanied her, began to bark, and would not be quieted. Suddenly she heard something moving in the grave, and a sound as though somebody was awaking from a long sleep. She fled, terrified, and told the people what she had heard. They went to the grave, opened it, and found that the dead had returned to life. They carried him home, and gave him some food. But he felt weak, and it was not until he had slept long and soundly that he began to speak. 'Mother,' he said, 'why did not you give me to eat when I asked you? Did not you hear me? I said, "I am hungry," and nudged you. I wanted to touch your right side, but I was unable to do so. I was compelled by a magic force to stand at your left side. You did not reply, but merely touched your side, saying, "That is a bad omen." When I saw you eating, I asked you to let me take part in your meal, but you did not answer, and without your permission I was not able to partake of any food. You said, "The fire crackles, and you threw some of your meal into it."

'When I was dead I did not feel any pain. I sat by my body, and saw how you prepared it for burial, and how you painted my face with our crest. I heard you, O mother, mourning at my grave. I told you that I was not dead, but you did not hear me. After four days I felt as though there was no day and no night. I saw you carrying away my body, and felt compelled to accompany it, although I wished to stay in our house. I asked every one of you to give me some food, but you threw it into the fire, and then I felt satisfied. At last I thought, "I believe I am dead, for nobody hears me, and the burnt food satisfies me," and I resolved to go into the land of the souls. Soon I arrived at a fork in the road. A much-trodden road led one way, while the other seemed to have been seldom used. I followed the former. I longed to die, and went on and on, hoping to reach the country of the deceased. At last I arrived at a steep rock, the end of the world. At the foot of the rock a river flowed sluggishly. On the other side I saw a village, and recognised many of its inhabitants. I saw my grandmother and my uncle who have long been dead, and many children whom I had once tried to cure. But many of those I saw I did not know. I cried, "Oh, come, have pity upon me! Take me over to you!" But they continued to wander about as though they did not hear me. I was overcome by weariness, and lay down. The hard rock was my pillow. I slept soundly, and when I awoke I did not know how long I had slept. I

stretched my limbs and yawned. Then the people in the village cried, "Somebody is coming! Let us go and take him across the river!" A boat came to where I stood, and took me to the village. Everyone greeted me kindly. I was going to tell them of this life, but they raised their hands and motioned me to be silent, saying, "Don't speak of these matters; they do not belong to us." They gave me salmon and berries to eat, but everything had a burnt taste, although it looked like good food; therefore I did not touch it. They gave me water, but when I was about to drink it I found that it looked green and had a bitter taste. They told me that the river which I had crossed was formed of the tears shed by the women over the dead; therefore you must not cry until your dead friend has crossed the river.

'I thought, "I came here to die, but the spirits lead a miserable life. I will rather endure the pains my mother inflicts upon me than stay here.' The spirits asked me to stay, but I was not moved by their entreaties, and left. As soon as I turned round the river had disappeared, and I found myself on a path that was seldom trodden by man. I went on and on, and saw many hands growing out of the ground, and moving towards me, as though they were asking something. Far away I saw a great fire, and close behind it a sword swinging around. When I followed the narrow path I saw many eyes, which were all fixed upon me. But I did not mind them, for I wanted to die, and I went on and on. The fire was still at a distance. At last I reached it, and then I thought, "What shall I do? My mother does not hear me. I hate the life of the spirits. I will die a violent death, and go to Tahī′t." I put my head into the fire, right where the sword was swinging round. Then all of a sudden I felt cold. I heard my dog barking and my mother crying. I stretched my limbs, peeped through the walls of my little grave, and saw you, O mother, running away. I called my dog; he came to see me, and then you arrived and found me alive. Many would like to return from the country of the spirits, but they dread the hands, the eyes, and the fire; therefore the path is almost obliterated.'

A similar story tells of a man's visit to the upper country, which is ruled by Tahī′t:

A man named Ky'itl'ā′c, who lived about seven generations ago, killed himself. When he died he saw a ladder descending from heaven, and he ascended it. At the head of the ladder he met an old watchman, who was all black, and had curly hair (? ?). He asked, 'What do you want here?' When Ky'itl'ā′c told him that he had killed himself, the watchman allowed him to pass. Soon he discovered a large house, and saw a kettle standing in front of it. In the house he saw Tahī′t, who beckoned him to come in. He called two of his people (who are called Kyēwak·ā′ō) and ordered them to show Ky'itl'ā′c the whole country. They led him to the Milky Way, and to a lake in which two white geese were swimming. They gave him a small stone and asked him to try and hit the geese with it. He complied with their request, and as soon as he had hit the geese they began to sing. This made him laugh, for their singing felt as though somebody tickled him. Then his companions asked him, 'Do you wish to see Tahī′t's daughters?' When he expressed his desire they opened the cloud door, and he saw two bashful young girls beyond the clouds. When he looked down upon the earth he saw the tops of the trees looking like so many pins. But he wished to return to the earth. He pulled his blanket over his head and flung himself down.

He arrived at the earth unhurt, and found himself at the foot of some trees. Soon he discovered a small house, the door of which was covered with mats. He peeped into it, and heard a child crying that had just been born. He himself was the child, and when he came to be grown up he told the people of Tahī't. They had heard about him before, but only then they learnt everything about the upper world. Ky'itl'ā'c told that those whose heads had been cut off had their eyes between their shoulders in the upper world.

Another man, named Gyinaskila'c, did not believe in Tahī't. He said to the people, 'Kill me! If I really go to Tahī't, I shall throw down fuel from heaven.' He was killed, and after a short time four pieces of wood fell down from heaven. Then the people knew that Ky'itl'ā'c's report was true.

In the second of these tales, reference is made to the Tlingit idea of transmigration of souls. Former authors state that man is born anew four times, and that the soul is then annihilated. I did not hear of any such restriction, but it may be that some notion of this kind obtains. The souls of animals also descend to the next generation, but there is no transmigration of souls between man and animal, or between animals of different kinds. There is particularly no transmigration of souls between man and his crest.

It is said that 'our world is sharp as a knife.' Although there is a mythical side to the idea, it seems to be said principally in a moral aspect. The saying continues, 'We must take care that we do not deviate from the straight course, for else we would fall off and die.' My informant explained this, saying, 'Once a boy did not believe that our world is sharp. He danced about and behaved foolishly. Then he ran a splinter of wood into his foot and died. Now he knew that our world is as sharp as a knife.'

I have not heard that Yētl, the great hero of their myths, is worshipped, but they believe that he will return. It is, however, not stated what he will do on his return, whether he will continue his adventures or benefit mankind. It must be borne in mind that Yētl, in all his exploits, by which he benefited man, did so against his will and intent.

The Tlingit pray to the sun to give them food and fair weather, but it does not seem that he occupies in any way a prominent place among their deities. They also pray and offer to the mountains and to the thunder, to the killer (*Delphinus orca*) and to the seals. Their religion is a nature worship. When praying they blow up eagle-down as an offering, and give to every being what they think it likes best. The mountains are asked for fair wind. When they hear a peal of thunder, they shake themselves and jump high up, crying, 'Take all my sickness from me!'

The killer is believed to upset canoes and take the crew with him. Him and the seal they ask for food. They believe in fabulous seal-men. When one of these is seen, they pour a bucket of fresh water into the sea.

I have not discovered any belief distinguishing the religion of the Haida from that of the Tlingit.

Tsimshian.—While the religion of the Tlingit and Haida seems to be a nature worship, founded on the general idea of the animation of natural objects, no object obtaining a prominent place, that of the Tsimshian is a pure worship of Heaven (Leqa'). Heaven is the great deity who has a

number of mediators called Nᴇqno'q. Any natural object can be a Nᴇqno'q, but the most important ones are sun and moon, spirits appearing in the shape of lightning strokes and animals. Nᴇqno'q designates anything mysterious. It is the supernatural will of the deity, as well as the whistle which is used in the dances and is kept a profound secret, and a mere sleight-of-hand. In one myth the master of the moon, the pestilence (Hai'atliloq), appears as a powerful deity. I suspect that this last idea is due to Kwākiutl influence. Heaven rules the destinies of mankind; Heaven taught man to distinguish between good and bad, and gave the religious laws and institutions. Heaven is gratified by the mere existence of man. He is worshipped by offerings and prayer, the smoke rising from fires being especially agreeable to him. Murderers, adulterers, and those who behave foolishly, talking to no purpose, and making noise at night, are especially hateful to him. He loves those who take pity upon the poor, who do not try to become rich by selling at high prices what others want. His messengers, particularly sun and moon, must be treated with respect. Men make themselves agreeable to the deity by cleanliness. Therefore, they must bathe and wash their whole bodies before praying. For the same reason they take a vomitive when they wish to please the deity well. They fast and abstain from touching their wives if they desire their prayers to be successful. They offer everything that is considered valuable—eagle-down, red paint, red cedar bark, good elk-skin lines, &c. The offering is burnt.

The Tsimshian do not always pray to Heaven directly, but far more frequently to his mediators. Thus they pray in a general way to the Nᴇqno'q: '*Nᴇqno'q, Nᴇqno'q! Sᴇmâ'yits, Sᴇmâ'yits! ramrâ'dᴇn! āyen tiᴇ'n qspäyā'nᴇksᴇn tlᴇ'rᴇnt! Nᴇqno'q! ramrâ'dᴇn!*' that is, 'Nᴇqno'q, Nᴇqno'q! Chief, chief! Have pity upon us! Else there will be nobody to make smoke under you! Nᴇqno'q! Have pity upon us!' Or praying for fair weather: '*Nᴇqno'q, Nᴇqno'q! Sᴇmâ'yits, Sᴇmâ'yits! ramrâ'dᴇn! tgyinē'e wāl tlᴇrᴇ'nt nᴇsᴇgya'tᴇnt. Man sä'ikya sī'ᴇnt ada ma d'ō ds'ānt!*' 'Nᴇqno'q, Nᴇqno'q! Chief, chief! Have pity upon us! Look down and see what those whom you made are doing! Pull up thy foot and sweep off thy face!' ('Pull up thy foot'=stop the rain; 'sweep off thy face'=take away the clouds.) The following is a prayer for calm weather: '*Lō'sᴇgya nā ksᴇnā'tlgᴇnt! Sᴇmâ'yit dᴇmwul gya'ksᴇt!*' 'Hold in thy breath, Chief! that it be calm!' Before eating they burn food; having done so they pray: '*Wa sᴇmâ'yits dᴇm ga'bᴇnguaa qpigä' ga'bᴇnmēe. Tawā'l māndᴇgua'a, tawā'l māndᴇgua'a tlgᴇranē'ᴇ. Gyī'ᴇnᴇm!*' 'Here! Chief! Here is for you to eat, part of our food. It is all that is left us! It is all that is left us! Now feed us!' In the same way the woman in the legend prays: '*Wa wa wa gyī'ᴇnᴇm hadsena's!*' 'Now, now, now feed us! fortunate one!' (name of a bird, a Nᴇqno'q).

The dead go to a place similar to that of the living. Our summer is their winter, our winter their summer. They have everything—fish, venison, and skins—in abundance.

If a special object is to be attained, they believe they can compel the deity to grant it by a rigid fasting. For seven days they have to abstain from food and from seeing their wives. During these days they have to lie in bed motionless. After seven days they may rise, wash themselves, comb the right side of their head, and paint the right side of their face. Then they might look at their wives. A less rigid form of fasting extends over four days only. To make the ceremony very successful, their

wives must join them. If the wife should not be true to the husband the effect of the fasting is destroyed.

The following beliefs and customs are connected with their religious ideas and ceremonies:—Twins are believed to control the weather; therefore they pray to wind and rain: 'Calm down, breath of the twins.' Whatever twins wish for is fulfilled. Therefore they are feared, as they can harm the man whom they hate. They can call the olachen and salmon, and are therefore called Sewihā'n=making plentiful.

The olachen is called halᴇmâ'tk, the Saviour. Certain ceremonies are prescribed when the first fish are caught. They are roasted on an instrument of elderberry-wood, of the form shown in the accompanying sketch. A handle is tied to the central rod, which is about three feet long. A short crosspiece is fastened to the rod about one foot from its end, and twigs are fastened to its outer ends, being tied to the central rod near its upper end. The man who roasts the fish on this instrument must wear his travelling attire: mittens, cape, &c. While it is roasted they pray for plenty of fish, and ask that they might come to their fishing ground. When the fish is turned round, all cry, *lawā'!* The fire must not be blown up. In eating the fish they must not cool it by blowing, nor break a single bone. Everything must be kept neat and clean. The rakes for catching the fish must be hidden in the house. The fish must not be left outside, but stored in boxes. The first fish that they give as a present to their neighbours must be covered with a new mat. When the fish become more plentiful, they are doubled up, and roasted on the point of a stick. After that they are treated without any further ceremonies.

Fig. 4.

Kwākiutl.—The Kwākiutl worship the sun, who is called K·ants'ō'ump (our father), A'ta (the one above), K·anskī'yi (our brother), K·ansnō'la (our elder brother), or Amiaē'qet (the one to whom we must be grateful). They pray to him and they give him offerings. His son is K·ānikilak· (with outspread wings), who descended from heaven and wandered all over the world, giving man his social institutions, customs, and arts. They pray to him also. After death the souls go to a country like ours, and continue to be what they have been on earth. The ghosts may reappear; to see them brings sickness and death.

The Kwākiutl have a belief regarding twins similar to that of the Tsimshian. They consider twins transformed salmon, and, as children of salmon, they are guarded against going near the water, as it is believed they would be re-transformed into salmon. While children they are able to summon any wind by motions of their hands, and can make fair or bad weather. They have the power of curing diseases, and use for this purpose a rattle called k·'oā'qaten, which has the shape of a flat box about three feet long by two feet wide. Their mother-marks are considered scars of wounds which they received when they were struck by a harpoon while still having the shape of salmon.

The Coast Salish.—The Coast Salish worship the sun and the great wanderer. The Çatlō'ltq call the latter Kumsnō'otl (our elder brother), a word which has been borrowed from the Kwākiutl. They pray to him *Ai kuaçqātō'mōtl, Kumsnō'otl, kums ē'tltᴇn!* (O Kumsnō'otl, give us to eat!) The Snanaimuq must not partake of any food until the sun is well up in the sky. The Sk·qō'mic seem to consider the great wanderer, whom they call Qā'is, the great deity. He is also called Qā'aqa and

Slaā'lEk·am. All these tribes believe that the touch or the seeing of ghosts brings sickness and death.

The Kutona'qa have a distinct sun-worship. They pray and sacrifice to the sun. Before beginning their council they put tobacco into a pipe and offer it three times to the sun, holding up the pipe-stem to it. This ceremony is called *wusitlwatlak·ō'nē* (=making the sun smoke). Then the pipe is turned round three times horizontally, a smoke being thus offered to the four points of the compass. They make hoops of twigs, and everyone ties to his a part of what he desires to have. A horse's hair indicates that horses are wished for. The hoop is hung to a tree as an offering to the sun. Before war expeditions, and to ward off disaster, they celebrate a great festival, in which the first joint of a finger is cut off as an offering to the sun. It is then hung to a tree. They also pierce their flesh on arms and breast with awls, cut off the piece they have thus lifted and offer it to the sun. The first-born child is sacrificed to him. The mother prays, 'I am with child. When it is born I shall offer it to you. Have pity upon us.' Thus they expected to secure health and good fortune for their families. These customs evidently correspond to the similar customs of the Blackfeet, although my informant maintained that the so-called sun-dance was never held by the Kutonaqa. In winter a large dancing ('medicine') lodge is built for dancing and praying purposes. Then they pray for snow in order to easily obtain game.

The dead go to the sun. One of the important features of their religion is the belief that all the dead will return at a future time. This event is expected to take place at Lake Pend Oreille. Therefore all Kutonaqa tribes used to assemble there from time to time to await the dead. On their journey they danced every night around a fire, going in the direction of the sun. Only those who were at war with any tribe or family danced the opposite way. The festival at the lake, which lasted many days, and consisted principally of dances, was celebrated only at rare intervals.

Shamanism and Secret Societies.

In the preceding account of the religious ideas of the Indians of British Columbia I have not mentioned shamanism, which forms a most important part of their religions, and which is closely connected with all their customs. All nature is animated, and the spirit of any being can become the genius of a man, who thus acquires supernatural powers. These spirits are called Yēk by the Tlingit: they are the NEqno'q of the Tsimshian. It is a remarkable fact that this acquiring of supernatural powers is designated by the Tsimshian, Bilqula, and Nutka by a Kwākiutl word (Tlōk·oala), which in these instances, however, is restricted to the highest degrees of supernatural power. This proves that the ideas of the Kwākiutl exercised a great influence over those of the neighbouring peoples, and for this reason I shall begin with a description of shamanism among the Kwākiutl.

The secrets of shamanism are confided to a number of secret societies which are closely connected with the clans of the tribes. Thus the art of the 'medicine man' (of the shaman proper) is derived from Haialikyawē, the ancestor of the gens of that name. The secrets of others are obtained by initiation. I failed to reach a fully satisfactory

understanding of this subject, which offers one of the most interesting but at the same time most difficult problems of North-West American ethnology. The crest of a clan and the insignia of the secret societies are acquired in the same way. They are obtained by marriage. If a man wants to obtain a certain carving, or the membership of a secret society, he must marry the daughter of a man who is in possession of this carving or who is a member of the secret society; but this can be done only by consent of the whole tribe, who must declare the candidate worthy of becoming a member of this society or of acquiring that crest. Notwithstanding this fact, the man who is thus entitled to become a member of the secret society must be initiated.

The insignia of all these societies are made of the bark of cedar, carefully prepared, and dyed red by means of maple bark. It may be said that the secrets are vested in these ornaments of red cedar bark, and wherever these ornaments are found on the north-west coast secret societies occur. I do not hesitate to say that this custom must have originated among the Kwākiutl, as it is principally developed among them, and as the other tribes whenever they have such societies designate them with Kwākiutl names. Historical traditions are in accord with this view.

I will not attempt in this place to describe all the secret societies and their insignia, my knowledge of them being still deficient, and an amply illustrated article having appeared in the 'Internationales Archiv für Ethnologie.' I shall describe, however, the general character of these societies and some of the most important among them.

The secret societies are allowed to meet and to perform their dances and ceremonies only in winter. The time of the year when they meet is called by most tribes Tsā′ēk·a, or Tsētsā′ēk·a (=the secrets). The following facts were observed among the Kwākiutl. During the Tsā′ēk·a season the whole tribe is divided into a number of groups which form secret societies. Among the Kwākiutl I observed some groups, the principal of which is called the Mē′emqoat (=the seals). It embraces the secret societies, principally the Hā′mats'a and the Nutlematl. Besides these the masks of the crane, Hā′maa, grizzly bear, and several others belong to this group. Among the other groups I mention the following:

2. K·ō′k·oskī′mō, who are formed by the old men.
3. Maa′mq'ēnok (=the killers, *Delph. orca*), the young men.
4. Mō′smōs (=the dams), the married women.
5. Kā′k·aō (=the partridges), the unmarried girls.
6. Hē′melk· (=those who eat continually), the old chiefs.
7. Kēki′qalak· (=the crows), the children.

Every one of these groups has its separate feasts, in which no member of another group is allowed to take part; but before beginning their feast they must send a dish of food to the Hā′mats'a. At the beginning of the feast the chief of the group—for instance, of the K·ā′k·aō—will say, 'The partridges always have something nice to eat,' and then all peep like partridges. All these groups try to offend the Mē′emqoat, and every one of these is offended by a particular action or object. The grizzly bear mask must not be shown any red colour, his preference being black. The Nutlematl and crane do not like to hear a nose mentioned, as theirs are very long. Sometimes the former try to induce men to mention their noses, and then they burn and smash whatever they can lay their

hands on; *e.g.* a Nutlematl blackens his nose; then the people will say: 'Oh, your head is black;' but if anybody should happen to say, 'What is the matter with your nose?' the Nutlmatl would take offence. Sometimes they cut off the prows of canoes because of their resemblance to noses. The Nutlematl must be as filthy as possible.

Sometimes a chief will give a feast to which all these groups are invited. Then nobody is allowed to eat before the Hā′mats'a has eaten, and if he should decline to accept the food offered him, the feast must not take place. After he has once bitten men he is not allowed to take part in feasts.

The chief's wife must make a brief speech before the meal is served. She has to say, 'I thank you for coming. Be merry and eat and drink.' If she should make a mistake, deviating from the formula, she has to give another feast.

From these brief notes it will be seen that the winter festivals, besides their religious character, are events of social interest in which merry-making and feasting form a prominent feature. The same has been observed among numerous American tribes.

Among the secret societies forming the group of the Mē′emqoat the Hā′mats'a is by far the most important. The Hā′mats'a is initiated by one of three spirits: Baqbakualanosī′uaē, Baqbakuā′latlē, Ha′maa or the human-headed crane. The ceremonies of initiation are as follows: In winter the inhabitants of the village assemble every night and sing four songs, accompanying the dance of the novice, who is accompanied by ten companions called Sâ′latlila, who carry rattles. When the dance is at an end they leave the house where the festival is celebrated, always surrounding the novice; they go all around the village, visiting every house. All of a sudden the novice disappears, and his companions say that he has flown away. Then his voice is heard in the woods, and everybody knows that he is now with the spirits. There he stays from one to five months, and the people believe that during this time he wanders all over the world. At the end of this term his voice is again heard in the woods. Birds are heard whistling on all sides of the village, and then the Indians prepare to meet the new Hā′mats'a. The sound of the birds' voices is produced by means of whistles, which are blown by the new Hā′mats'a and by those who were initiated at former occasions, but they are kept a profound secret from all those who are not initiated.

The father of the young Hā′mats'a invites the inhabitants of the village to a feast. The guests sit down in the rear of the house, everyone carrying a stick for beating time. Two watchmen, each carrying a rattle in shape of a skull, stand on each side of the door, and are occasionally relieved. A chief stands in the centre of the house, two messengers attending him. These he despatches to the women of the gens of which the new Hā′mats'a is a member, and they are ordered to dance. The interval until the women are dressed up and make their appearance is filled with railleries between the messengers. As soon as the watchmen see a woman coming they begin swinging their rattles, and then the guests begin singing and beating time with their sticks. The woman enters the house, and, turning to the right, goes around the fire until she arrives in the rear part of the house. Then the guests stop singing and beating time until the dance begins. In dancing the woman first faces the singers; then she turns to the left, to the fire, and to the right, and, finally, faces the singers again. She leaves the house by going along the left side of the fire. When the

feast is almost at an end, a terrible noise is heard on the roof of the house, where the new Hā'mats'a is dancing and whistling. Sometimes he throws the boards forming the roof aside and thrusts his arms into the house. Then he disappears again, and his whistles are heard in the woods.

His father requests the men to assemble early in the morning, and they set out to meet the young Hā'mats'a in the woods. They take a long rope made of cedar bark, and, having arrived at an open place in the forest, lay it on the ground in form of a square. They then sit down inside the square, all along the rope, which represents the platform of the house, and sing four new songs composed for the purpose. The two first ones are in a quick binary measure, the third is in a five-part measure, and the last has a slow movement. One man dances in the centre of the square. Meanwhile the mother of the new Hā'mats'a invites the women and the old men to a feast, which is celebrated in the house. All the men are painted black; the women red. The latter wear button-blankets, head-rings of cedar bark dyed red, and their hair is strewn with eagle-down. The men who are in the forest wear head-rings and necklets of hemlock branches. While they are singing and dancing the new Hā'mats'a makes his appearance. He looks pale and haggard, and his hair falls out readily. He wears three neck-rings, a head-ring, and arm-rings made of hemlock branches, but no shirt and no blanket. He is immediately surrounded by his companions, and the men return to the village singing the new songs. When the women hear them approaching they come out of the house and expect them on the street, dancing. They wish to please the new Hā'mats'a, for whosoever excites his anger is at once attacked by him. He seizes his arm and bites a small piece of flesh out of it. It is said that in fact this is done with a sharp, bent knife, but I doubt whether this is true. At the end of the Tsā'ek'a season the Hā'mats'a must compensate every single person whom he has bitten with a blanket or two. In the evening the people assemble in the house of the Hā'mats'a's father for singing and dancing. If anything should displease the Hā'mats'a, he rushes out of the house and soon returns carrying a corpse. His companions continue to surround him in all his movements. He enters the house and, turning to the right, goes around the fire until he arrives in the rear of the house. As soon as the old Hā'mats'a see the corpse they make a rush at it, and fight with each other for the flesh. They break the skull and devour the brains, and smash the bones to get at the marrow. The companions cut large slices from the body, and put them into the mouth of the young Hā'mats'a, who bolts them. At the end of this ceremony the father of the young Hā'mats'a presents everyone with bracelets of copper.

The new Hā'mats'a dances four nights—twice with rings of hemlock branches, twice with rings of dyed cedar bark. Strips of cedar bark are tied into the hair, which is covered with eagle-down. His face is painted black; he wears three neck-rings of cedar bark, arranged in a peculiar way, and each of a separate design. Strips of cedar bark are tied around his wrists and ankles. He dances in a squatting position, his arms extended to one side, as though he were carrying a corpse. His hands are trembling continually. First he extends his arms to the left; then he jumps to the right, at the same time moving his arms to the right. His eyes are staring, his lips protruding voluptuously.

The Indians are said to prepare the corpses by laying them into the

sea and covering them with stones. The Çatlō′ltq, who also practise the Hā′mats'a dances, make artificial corpses by sewing dried halibut to the bones of a skeleton and covering its skull with a scalp.

The new Hā′mats'a is not allowed to have intercourse with anybody, but must stay for a whole year in his rooms. He must not work until the end of the following dancing season. The Hā′mats'a must use a kettle, spoon, and dish of his own for four months after the dancing season is at an end; then these are thrown away and he is allowed to eat with the other people. During the time of the winter dance a pole, called *hā′mspiq*, is erected in the house where the Hā′mats'a lives. It is covered with red cedar bark, and made so that it can turn round.

Another secret society is called Mā′mak·'a (from *mak·qa′*, to throw). The initiation is exactly like that of the Hā′mats'a. The man or woman who is to become Mā′mak·'a disappears in the woods and stays for several months with Mā′mak·'a, the genius of this group, who gives him a magic staff and a small mask. The staff is made of a wooden tube and a stick that fits into it, the whole being covered with cloth. In dancing the Mā′mak·'a carries this staff between the palms of his hands, which he holds pressed against each other, moving his arms up and down like a swimmer. Then he opens his hands, separating the palms, and his staff is seen to grow and to decrease in size. When the time has come for the new Mā′mak·'a to return from the woods, the inhabitants of the village go in search of him. They sit down in a square formed by a rope, and sing four new songs. Then the new Mā′mak·'a appears, adorned with hemlock branches. While the Hā′mats'a is given ten companions, the Māmak·'a has none. The same night he dances for the first time. If he does not like one of the songs, he shakes his staff, and immediately the spectators cover their heads with their blankets. Then he whirls his staff, which strikes one of the spectators, who at once begins to bleed profusely. Then Mā′mak·'a is reconciled by a new song, and he pulls out his staff from the stricken man's body. He must pay the latter two blankets for this performance, which, of course, is agreed upon beforehand.

This may suffice as a description of the secret societies. The dance of the Mā′mak·'a shows the idea of the natives regarding the origin of sickness. It is the universal notion of an object having entered the body of the sick man; by its removal he is restored to health. The Mā′mak·'a and the ordinary medicine man have the power of finding such objects and of removing them by means of sucking or pulling them out with carved instruments, by the help of the noise of rattles and incantations. Among the objects thrown into the body to cause sickness, quartz is considered one of the most dangerous. Sickness is also produced by the soul leaving the body. The shaman is able to find it and to restore it. Besides the Mā′mak·'a, the descendants of Haialikyawē and those initiated in his mysteries are considered the most powerful medicine men. Magic power can also be acquired by a visit to the fabulous mountain Ts'ilkyumpaē, the feather mountain, on which the magic eagle-down and the quartz which enables the possessor to fly are found.

The Tsimshian have four secret societies, which have evidently been borrowed from the Kwākiutl—the Olala or Wihalait, Nō′ntlem, Mē′itla, and Sᴇmhalait. The words Olala, Nō′ntlem (=mad), and Mēitla have been borrowed from the Kwākiutl. Wihalait means the great dance; Sᴇmhalait, the ordinary dance. The Olala corresponds to the Hā′mats'a of the Kwākiutl; the Nō′ntlem to the Nūtlmatl. The Olala is (or rather

was) a prerogative of the Gyitqā'tla and Gyispaqlâ'ots, who obtained them by intermarriage with the northern Kwākiutl tribes. There exists a tradition among the Tsimshian referring to the fabulous origin of these societies by the initiation of a man; but it is evident that this legend has been invented in analogy to others of a similar character. Historical traditions, and the fact that the Olala is confined to the southern Tsimshian tribes, prove that they are of foreign origin.

A man who is not a member of a secret society is a 'common man.' He becomes a middle-class man after the first initiation, and attains higher rank by repeated initiations. The novice disappears in the same way as among the Kwākiutl. It is supposed that he goes to heaven. During the dancing season a feast is given, and while the women are dancing the novice is suddenly said to have disappeared. If he is a child he stays away four days; youths remain absent six days, and grown-up persons several months. Chiefs are supposed to stay in heaven during the fall and the entire winter. When this period has elapsed they suddenly reappear on the beach, carried by an artificially-made monster belonging to their crest. Then all the members of the secret society to which the novice is to belong gather and walk down in grand procession to the beach to fetch the child. At this time the child's parents bring presents, particularly elk-skins, strung upon a rope as long as the procession, to be given at a subsequent feast. The people surround the novice and lead him into every house in order to show that he has returned. Then he is taken to the house of his parents and a bunch of cedar bark is fastened over the door, to show that the place is tabooed, and nobody is allowed to enter. The chief sings while it is being fastened. In the afternoon the sacred house is prepared for the dance. A section in the rear of the house is divided off by means of curtains; it is to serve as a stage, on which the dancers and the novice appear. When all is ready, messengers, carrying large carved batons, are sent round to invite the members of the society, the chief first. The women sit down in one row, nicely dressed up in button-blankets, and their faces painted red. The chief wears the Amhalait—a carving rising from the forehead, set with sea-lion barbs, and with a long drapery of ermine-skins—the others, the cedar-bark rings of the society. Then the women begin to dance. After a while a prominent man rises to deliver a speech. He says: 'All of you know that our novice went up to heaven. There he made a mistake, and has been returned. Now you will see him.' Then he begins the song, the curtain is drawn, and masked dancers are seen surrounding the novice, and representing the spirits he has encountered in heaven. At the same time eagle-down is blown into the air. The novice has a pair of clappers between his fingers, and for every new initiation he receives an additional clapper. After the dance is over, the presents which were strung on the rope are distributed among the members of the secret society.

The novice has a beautifully-painted room set apart for his use. He has to remain naked during the dancing season. He must not look into the fire, must abstain from food and drink, and is only allowed to moisten his lips occasionally. He has to wear his head-ring continually. After the ceremonies are all gone through, the festival of 'clothing the novice' is celebrated. He sits in his room quietly singing while the people assemble in the house. His song is heard to grow louder and louder, and at last he makes his appearance. He has put off his ring of

cedar bark. Then the people try to throw a bear-skin over him, which they succeed in doing only after a severe struggle. At this feast all societies take part, each sitting grouped together. The common people stand at the door. This ends the initiation ceremonies.

The festival of 'clothing' is also celebrated by the Kwākiutl, when it seems to indicate the end of the trance of the novice.

The initiation is repeatedly celebrated, the rank of the person being the higher the more frequently he has gone through the ceremonies. But nobody, chiefs excepted, can be a member of more than one secret society. It seems that the SEmhalait are considered a preparatory step for the initiation into other societies, so that every person must have been SEmhalait before he can become Mēitla, Nōntlem, or Olala. A Mēitla, however, can never become Nōntlem or Olala. Those who passed twice through the SEmhalait ceremony are called Ts'ē'ik. The Mēitla have a red head-ring and red eagle-downs, the Nōntlem a neck-ring plaited of white and red cedar bark, the Olala a similar but far larger one. The members of the societies receive a head-ring for each time they pass through these ceremonies. These are fastened one on top of the other. The Nōntlem destroy everything, carry firebrands, and tear live dogs to pieces, which they devour. They correspond exactly to the Nūtlmatl and Nōntsistatl of the Kwākiutl.

The secret societies have no connection whatever with the gentes. Generally the father determines to what society each child is to belong, and has them initiated by proxy, so that they may belong to the middle class from childhood.

The Haida borrowed these customs from the Tsimshian, and sometimes perform the Mēitla and Olala dances; but the Tsimshian maintain that they have no right to do so. Their dance, corresponding to the SEmhalait of the Tsimshian, is that of the shaman, the Sk·aga, the initiation being identical with that of the Tsimshian SEmhalait. The Sk·aga has a number of head-rings, one on top of the other, corresponding to the number of ceremonies he went through.

The shamans proper of the Tlingit, Haida, and Tsimshian are initiated by a spirit after long fasting. Those of the Tlingit and Haida acquire their knowledge of the mysteries of shamanism by tearing out the tongues of an otter, an eagle, and several other animals. In doing so they must use a bundle of twigs strung together with spruce roots for catching the blood that flows from the animal's tongue. Those twigs which have not come into contact with the blood are taken out. Sometimes a piece or the whole of the tongue is wrapped in those bundles, and, in cases of great emergency, worn by the shaman round the neck to endow him with great power over spirits (see 'Journal Amer. Folk-Lore,' i. p. 218). The dignity seems to be hereditary. They wear long hair, which must never be touched with the hands, and is therefore extremely filthy and matted. They wear a necklace set with bone ornaments, a long curved piece of bone in the septum of the nose, a bird's head on the breast, a rattle, and a carved staff. Their art consists in extracting the sickness or in finding and restoring the soul of the sick person. In trying to find it three or four shamans sing and rattle over the sick person until they declare to have found the whereabouts of his soul, which is supposed to be in possession of the salmon or olachen, or in that of the deceased shaman. Then they go to the place where it is supposed to be and by singing and incantations obtain possession of it and enclose it in a hollow

carved bone. Then mountain-goat tallow, red paint, eagle-down, and other valuable objects are burnt, and the soul held over the fire. The bone is then laid upon the sick man's head, the shaman saying, 'Here is your soul. Now you will be better and eat again.' Sometimes the soul is supposed to be held by a shaman, who is paid for returning it.

A supposed sorcerer is tied up and starved until a confession is made, when he is driven into the sea to expel the evil spirit. Should he refuse to confess he is either starved to death or placed on shore at the limit of low tide, and, being bound, is drowned when the water rises. Sorcery is practised principally by means of parts of the body of the person to whom the sorcerer wishes to do harm. If it is believed that a man died in consequence of being bewitched, the Tsimshian take the heart from the body and put a red-hot stone into it. They wish at the same time that the enemy should die. If the heart burst their wish is expected to be fulfilled; if not, it is a sign that their suspicions were unfounded.

The shamans of the Coast Salish go into the woods in order to be initiated. They swim in ponds and wash their bodies with cedar branches, and thus prepare themselves to meet the spirits and the fabulous double-headed snake who give them their supernatural powers. They cause sickness by making bits of quartz and wood fly into the body of their adversary, and heal the sick by removing these objects. To show their power they perform dances in certain festivals in which they pretend to cut their bodies with knives; the blood is seen to flow from the wounds; but when they move their hands over them no trace of the cuts is to be seen. At the burial, food is burnt for the dead on the beach. On this occasion the shaman throws presents for the dead into the fire on behalf of the mourners. He then affirms that he sees the deceased person's spirit, who speaks to him. In the winter dances each shaman wears the painting or the mask of the spirit who initiated him.

The shamans of the Kutona′qa are also initiated in the woods after long fasting. They cure sick people, and prophesy the result of hunting and war parties. If this is to be done, the shaman ties a rope around his waist and goes into the medicine-lodge, where he is covered with an elk-skin. After a short while he appears, his thumbs firmly tied together by a knot which is very difficult to open. He re-enters the lodge, and after a short time reappears, his thumbs being untied. After he has been tied a second time he is put into a blanket, which is firmly tied together like a bag. The line which is tied around his waist, and to which his thumbs are fastened, may be seen protruding from the place where the blanket is tied together. Before he is tied up, a piece of bone is placed between his toes. Then the men pull at the protruding end of the rope, which gives way; the blanket is removed and the shaman is seen to lie under it. This performance is called k·′eqnᴇmnā′m (= somebody cut in two). The shaman remains silent, and re-enters the lodge, in which rattles made of pieces of bone are heard. Suddenly something is heard falling down. Three times this noise is repeated, and then singing is heard in the lodge. It is supposed that the shaman has invoked souls of certain people whom he wished to see, and that their arrival produced the noise. From these he obtains the information and instructions which he later on communicates to the people.

LINGUISTICS.

I. Tlingit.

Obtained from Mrs. Vine, Victoria, a native of the Stik'īn tribe.

PHONETICS.

Vowels: a, e, E, i, o, u.

Consonants: d, t; gy, ky; g, k, k‘; g·, k·; w, r, q, Q;
h, H, y; n; s, c; dz, ts; dj, tc; dl, tl.

The labials are absent. The difference between surds and sonants is very slight. I find in my lists a great number of cases in which for the same sound both surds and sonants are used promiscuously. The difference is so slight that I am inclined to think the language has only surd-sonants, which we apperceive by the means of our surds and sonants, and that they are for this reason considered two sounds. The *r* is a very deep guttural, the mouth assuming at the same time the position for pronouncing *w*, the lips only being a little further apart. The uvula vibrates very little, and thus it happens that the sound is very much like *w*. In many cases, particularly when preceding *u*, it is very difficult to distinguish both sounds. There seems to be a *dz* and *dj*, the sonants corresponding to *ts* and *tc*; but as in all instances I was just as much inclined to write the latter, I have mostly applied the latter form. The hiatus is very frequent, and occurs after all consonants. No combinations of consonants occur in the beginning of the word, except *dl* and *tl*, followed by a guttural, and perhaps *s* followed by the same. All letters can be initial and terminal sounds. I found the following terminal combinations of consonants:

qk			ks	kc	kts		kt	ktl
nk		nq	k·s				k·t	k·tl
sk						qtc	qt	
ck				nc		ntc		ntl
tk						stc		tctl
tlk	tlk·							

Sonants occur very rarely at the end of words, but this may be accounted for by the indefinite character of these sounds. Combinations of consonants are very rare. I do not attempt to give a list, as it is in many instances doubtful whether the word is really a single word or a compound.

GRAMMATICAL NOTES.

THE NOUN.

The Tlingit language has no grammatical sex and no separate forms for singular and plural. As Wemiaminov states that there is a plural, I have made frequent attempts to find it, but my search has been in vain, and I agree with Krause, who states that there is no separate form for the plural. In two or three instances I found the terminal vowel of nouns repeated, the word expressing at the same time a plural; but I have reason to believe that this repetition has merely euphonic reasons, as it is also found in other cases, and as the plural of the same word has frequently the same form as the singular: *tlōō* and *tlō*, noses. Wemiaminov mentions the plural *t'ek·*, stones (singular *t'e*), but I find in my collection *dēq t'e*, two stones. If it is necessary or desirable to state expressly that the plural is meant *k·toq*, a number of—, is placed after the noun. It seems to me probable that this is the plural referred to by Wemiaminov and spelled—khth. I have not found any indication of the existence of cases, not even of the instrumentalis mentioned by Wemiaminov.

Compound nouns are of very frequent occurrence, the components being placed side by side:

ca qā'wu, hair = head hair.
k·'ōs t'aktl, ankle = leg knuckle.
sE'sa a'sē, mast = sail tree.
ts'ak· sēt, necklace = bone necklace.
k·a tōrū', titmouse = man heart.
Dēkyī nō, name of an island = far from the coast, rock.
tāō s'ā'te, thief = steal master.
gūts rē tō'tli, Gallinago Wilsoni = cloud place bird.

Local adverbs enter frequently into compound words of this kind:

dz'ēk· da kēt, pipe = smoke around box.
tō uq rirē't, whistle = into blow instrument.
an k·a nāgu. Arnica cordifolia = town on medicine.
diq kara kidjē't, horse = back upon sit.
gan da da gū'gō, woodpecker = tree-outside pick.
k'iri t'ē'k·'ē, icicle = above ice.
k·an yiq k·u atē', aurora = fire-like weather colour.
kin dē tcunē't, Anas boschas = moving straight up.

The names of colours are compound words:

k·an yi'qatē, red = fire-like colour.
tlēd yiqatē, white = snow-like colour.
kētl ha'tlē yiqatē, yellow = dog dung colour.

THE ADJECTIVE.

The adjective follows the substantive to which it belongs, except when it has a verbal meaning:

tcātl qōk, dried halibut.
wāt curō', half fathom.
kētl gE'tskō, young dog.
aqa darē't, oar = long paddle.
tlāk· rīdzē, reed = wide grass.
hit tlēn, large house.

When the adjective stands for our adjective with the verbum substantivum, it generally precedes the substantive:

a tlēn hit, that is a large house.

NUMERALS.

Cardinal Numbers.

1, *tlēk·'*.
2, *dēq*.
3, *natsk'*.
4, *dāk·'ō'n*.
5, *kēdjin*.
6, *tlē durcu'*.
7, *daqa durcu'*.
8, *natska durcu'*.
9, *gō'cuk·*.
10, *djinkāt*.
11, *djinkāt k·a tlēk·'*.
20, *tlē k·ā*.
30, *natsk' djinkā't*.
40, *dak·' ō'n djinkā't*.
50, *kēdjin djinkā't*.
60, *tlē durcu' djinkā't*.
70, *daqa durcu' djinkā't*.
80, *natska durcu' djinkā't*.
90, *gō'cuk· djinkā't*.
100, *kēdjin k·ā*.
200, *djinkā't k·ā*.
300, *natsk djinkā't k·ā*.
400, *dak·' ō'n djinkā't k·ā*.

Four is evidently the second two, five a derivative from *djin*, hand, while the numbers from 6 to 8 are the other one, two, three. Ten seems to mean both hands; 20 is one man; 100, five men; while the numbers from 30 to 90 mean three, four, five, &c. tens.

In counting men the following numerals are used:

1 man *tlē nEq k·ā*.
2 men *dEq nEq k·ā*.
3 men *natskyē nEq k·ā*.
4 men *dak·'ōnē' nEq k·ā*.
5 men *kēdjinē' nEq k·ā*.
6 men *tlē durcu' nEq k·ā*.

The same numerals may be used in counting dogs.

Ordinal Numbers.

The following ordinal numbers differ to some extent from those given by Wemiaminov, and appear in parts doubtful:

cuk·a', the first.
i'ta, the second.
t'ara(dē'a), the third.
anira(dē'a), the fourth.
tlaqk·ara(dē'a), the fifth.
tlē durcura(dē'a), the sixth.
daqa durcura(dē'a), the seventh.
natska durcura(dē'a), the eighth.

So far as I was able to discover, the cardinal numbers are generally used in place of the ordinal numbers.

Numeral Adverbs.

These are formed by adding the suffix *-dahē'n* to the cardinal numbers.

tlēdahē'n, once. *natsk' dahē'n*, three times.
daqdahē'n, twice. *dak·'ōn dahē'n*, four times.

Distributive Numbers.

The cardinal numbers are at the same time distributives. I collected the following examples:

tlē k·a nᴇq and *tlē nᴇq*, one to each. *natskyē nᴇq*, three to each.
dᴇq nᴇq, two to each.

It will be observed that in this instance that form of numeral is used which denotes a number of men. It is probable that when other substantives are referred to the other numerals take their place.

THE PRONOUN

Personal Pronoun.

There are two forms of the personal pronoun, which may be designated the ordinary and the selective forms. The difference of these forms will best be made clear by giving examples: To the question, Who is there? I answer, *qat* (I), which is the ordinary form; while to the question, Who among all of you will help me? I answer, *qatc* (I).

Besides these we find two forms of the personal pronoun which are used in the inflexion of the verb: one in inflecting the transitive, the other in inflecting the intransitive verb, the latter being at the same time the object of the transitive pronoun. This makes it probable that the intransitive verb is really impersonal.

	Ordinary	Selective	Intransitive	Transitive	
				Subjective	Objective
Singular, 1st person	qat	qatc	qat	qa (q)	qat
„ 2nd „	woe'	woe'tc	ī	ī	ī
„ 3rd „	hu	hōtc	—	(a)	—
Plural, 1st „	ohā'n	ohā'ntc	ha	tō	ha
„ 2nd „	riwa'n	riwā'ntc	rī	rī	rī
„ 3rd „	has	hastc	has	has (a)	has

The transitive and intransitive forms must not be considered prefixes, as they are not inseparable from the verb.

Demonstrative Pronoun.

Krause and Wemiaminov give the demonstrative pronouns: *yatat*, this; and *yutat*, that. Krause states that the adjective form is *ya* and *yu*. I have no example of this kind in my list. There exists a demonstrative word *a*, which is very extensively used.

a tō, something inside. *aq ari agᴇ?* is that mine?
a tlēn hit, that large house. *hit a tlēn a*, that is a large house.

The following are evidently derivatives from the same demonstrative stem:

aq ari aua, that is mine. *hit g'ᴇ'tsgō asia'*, that is a small house.
i hiti asia, that is your house.

Note.—The demonstrative *wē* is found twice in my collection:

wōtc qat wu sī nēq, that man saved me.
wē atqa' qat sī nēk', that food me makes sick.

Note.—The personal and possessive pronouns, third person, are sometimes used with the termination *-tlt*, denoting that the person is at a distance, and thus receive a demonstrative meaning:

tōtlt ari aua, it is his, or that man's. *hastlt*, they (at a distance).

Possessive Pronoun.

The possessive pronoun has two forms, which are derived from the personal pronoun. The following form is most frequently found; it precedes the noun to which it belongs:

Singular, 1st person,	aq.		Plural, 1st person,	hā.
„ 2nd „	ī.		„ 2nd „	rī.
„ 3rd „	tō.		„ 3rd „	hastō.

While in this form the noun is not altered, in the following it takes the suffix *-ri*:

Singular, 1st person,	aq—ri.	Plural, 1st person,	hā—ri.
„ 2nd „	ī—ri.	„ 2nd „	rī—ri.
„ 3rd „	tō—ri.	„ 3rd „	hastō—ri.

I am not able to give any rule as to the use of these forms. The substantive possessive pronoun is formed by the demonstrative *a* and the second possessive form: *aq a ri*, mine (=my that).

Note.—The suffix *-ri* is sometimes contracted with the terminal sound of the noun:

aq hiti, my house; instead of *aq hit—ri*.

THE VERB.

In discussing the pronoun we stated that there are two forms, one for the transitive, the other for the intransitive verb, the latter being identical with the objective case of the transitive pronoun. This makes it probable that the intransitive verb may be impersonal, a theory which is the more probable on account of the remarkable particles used with these verbs. In Tlingit all verbs are transitive which express an activity, even in cases in which we do not use an object; all verbs expressing a state are intransitive, and for this reason our passive is rendered in the same way. Following is a list of transitive and intransitive verbs in the first person singular:

Intransitive Verbs.

qat rᴇ nēk', I am sick.
qat rᴇ ta uwa ha', I am sleepy.
qat wu di quē'tl, I am tired.
qat ran uwa ha', I am hungry.
qat tli tsēn, I am strong.
qat wu nēq, I recover from sickness, I am saved.
qat kawawᴇ'tl, I break down.

In another group of such verbs the pronoun is placed after the stem.

Tlingit qat, I am a Tlingit.
ank·ā'ō qat, I am rich.
icā'n qat, I am poor.
gāeu qat, I desire.

Transitive Verbs.

at qa qa, I eat (it).
qa aqtc, I hear.
qa djūn, I dream.
qa tl'ēq, I dance.
qa cī, I sing.
qa tēn, I see.
qa ta, I sleep.
k·'ān qa gaō, I am angry.
yuq'a qa tᴇñ, I speak.
at qa saē', I cook.
qa tana', I drink.
qa tlik', I open my eyes.
at qa cō'uk·, I laugh.
qa ce gōk, I know to——
qa gōt, I walk.
qa t'iqt, I pound.
qa tᴇn, I carry.

The verb, more especially the intransitive verb, appears frequently combined with certain particles, the meaning and origin of which I cannot explain. Former students of the Tlingit language failed to separate these particles from the words with which they are connected. Therefore the greater number of words of Wemiaminov's, as well as of other, lists are really compounds. I give first an alphabetic list of these particles. In those cases in which they may be omitted I have placed them in brackets.

dē — *dē qat ran uwa ha*, I am growing hungry.
dē wu di quē'tl, I am growing tired.
[*dē*] *ra k·ē na ē'n*, it is growing to be daylight.

dē — [*dē*] *k·ē wa a'*, it is daylight.
[*dē*] *rī sē·tē'nagE?* did you see them?
dē k·uk·qoatēn, I shall leave.
dē qat ri sēnē'q, you have saved me!
dē qa gōdē'n, I have gone.
ga'cu dē qa gōd, I wish to go.
dē rEn at qoa qa, I have eaten.
dē aq tana', I have drunk.

ku — *ku wat*, tall. *ku datl*, heavy.
ku watl, small. *ku tla*, stout.

ku seems to imply a reference to personal appearance.

k·u, weather, out-of-doors:

k·ū siū't, it is cold. *k·ū ti tl'ek·*, it is wet.
k·ū re ta, it is warm. *k·ū tli guts*, it is cloudy.
k·ū wa quk·, it is dry.
k·ūgū'ts, horizon, probably belongs to this group.
k·'anyiqk·ūwatē', aurora; fire like out-of-doors colour.

ra, *rE* — *ī rE nēk'*, you are sick. *rE k'ē*, good.
ha rE nē'gūn, we were sick. *rE sū'*, a short time ago.
qat rE ta uwa ha, I am sleepy. *rE dEtl*, heavy.

It is doubtful whether the following are derived from the same root:

at i ra qa, you have eaten. *tō ra aqtc*, we know.

na — *na tlē*, far
ttētl kyē qat wu na tlitcēn, I am growing weak.
dē ra kē na ēn, it is growing to be daylight.
hin ra rE na t'ēn, the water begins to be warm.
hin ra na s'Et, the water begins to be cold.
aq (1) *īc* (2) *na* (3) *nā'nēk·'* (4), if (4) my (1) father (2) should die (3).
k·u na tē'nnēk·', if he should leave.

From these examples it would seem that *na* designates the commencement of a certain state.

qat wu ti quē'tl, I am tired. *wu ti tl'ek·*, it is wet.
yiq ctuq ti nēk', I feel sick (*yiq* = like).

wa — *a ka wa qats*, clear sky. *wa quk·*, dry.
wa sE ku datl? is it heavy? *a ra ka wa dan*, it is snowing.
k·ē wa a, it is daylight.

wu — *wu nēk'*, he (absent) is sick.
tlētl qat wu nēk', I am not sick.
tlētl qat wuck'E', I am bad.
tlētl wu dEtl, light (not heavy)
tlētl wu tli tsē', easy.
tlētl wu q cEgōk, I cannot——
tlēgitl qat wu nēk'? Am I not sick?
gutl qat wu nēk', may be I am sick.
ī wu tli tsēngE? are you strong?
qat wu nēk', I am growing sick.
resū' wu nēk', I just got sick.
qat wu tlitsē'n, I am growing strong.
qat wu nēq, I recover from sickness, I am saved.
qat wu ti quē'tl, I am tired.
wu tli qun, thin.
wu na, dead.
dūq wu stanēn, it was raining.
has wu tō sētē'n, we see them.

In the great majority of cases in which *wu* is used the state (or action?) expressed by the verb is still incomplete, not yet or not longer existing, or existing at a distance. Thus it would appear that the particle *wu* denotes the 'not actually being.' It seems doubtful whether the *wu* of the last example can be classed with the rest. It is remarkable that this particle appears very frequently combined with others, especially so with *ti* and *tli*.

yē — *yē q sinē*, I have done it.
John yē s'ak· ku wat, John is tall (John is bone-long).
yē qat s'ak· ku watl, I am small (I am bone-short).
yē qat ku tla', I am stout.

yē — *aka yē qaō*, I put it on top of——
rE k'e yē k'a, he is a good man.
tlī tsēn yē k'a, he is a strong man.

It may be that this is a *verbum substantivum*; at least it seems possible to class all the examples given here in such a way.

tlī — *tlī ān*, good-natured. *tlī tsē*, difficult.
tlī tsēn, strong. *ck'aq tlī nēk'*, I pretend to be sick.
k'ū tlī guts, cloudy. *ck'aq qa tlīqa*, I pretend to cut.
tlī wus, strong (rope). *tlī ts'a*, later on.
wu tli qun thin.

To these particles might be added one which frequently, although not regularly, precedes the future tense, and in some instances also the past.

kyē — *kyē qat k'uk ra nēk'*, I shall be sick.
tlētl kyē qat wu na tli tsēn, I am growing weak.
tlēgītl kyē qat k'uk wu nēk', am I not going to be sick?
tlētl kyē qat wu nēk'tc, I have not been sick.
tlēgitl kyē nēk'tcēn? have you not been sick?

The following I found only in one single instance:

dāg sētē'n, it is raining. *dāg wu stanēn*, it was raining.
ā wu dāg ganē'n, the sun was shining.

Tenses.

Wemiaminov states that there are six tenses: present, imperfect, perfect, plusquamperfect, future, futurum exactum. My collections contain only the present, past (imperfect), and future tenses, which I give here in paradigmatic form:

nēk', sick.

——		Present Tense	Imperfect	Future
Singular,	1st person	qat rE nēk'	qat (rE) nē'gūn	(kyē) qat k·ug· rE nēk'
„	2nd „	ī rE nēk'sE	ī (rE) nē'gunEsE	(kyē) ī k·ug· rE nēk'
„	3rd „	rE nēk'	(rE) nē'gūn	(kyē) k·ug· rE nēk'
Plural,	1st „	ha rE nēk'	ha (rE) nē'gūn	(kyē) ha k·ug· rE nēk'
„	2nd „	rī rE nēk'	rī (rE) nē'gūn	(kyē) rī k·ug· rE nēk'
„	3rd „	has rE nēk'	has (rE) nē'gūn	kyē has k·ug· rE nēk'

In inflecting the transitive verb, the pronoun is placed immediately before the verb. In many instances the verb has an indefinite object, *at*, which is placed before the subject: *at qa qa*, I eat (it): *at qa cī*, I sing (it); *at qa saē'*, I cook (it). In compound verbs which consist of a stem denoting the action or state, and attributes limiting the action as to manner, place, or time, the subject is placed between these two parts, and thus an apparent infixion originates:

sk'a (1) *qa* (2) *da* (3) *ts'ēk* (4), I smoke = mouth (1) I (2) around (3) smoke (4).
ka (1) *qa* (2) *tlqEktl* (3), I rub with pestle = upon (1) I (2) rule (3).
tō (1) *qa* (2) *uq* (3), I (2) blow (3) into (1).

The following forms must be explained in the same way, although I am not able to translate the elements of these words. The place of the pronoun is indicated by a dash:

k'ant—wa nuk, angry (*k'an*, angry). *k'an—raō*, cross (*k'an*, angry).
yē—sinē, to do (*si*, to make). *su—s'ēt'ē'n*, to think of—.
yūq'ā—tEñ, to speak. *a—djūn*, to dream.
a—tl'ēq, to dance.

As a rule, the object is placed before the subject, but when the object is a pronoun and has a separate objective form the sequence may be reversed. *Has*, the third person plural of the personal pronoun, always precedes the object; therefore it seems probable that it is an attribute to the pronoun, limiting it to the plural. It

also precedes the first part of compound verbs: *has tō uq*, they blow into. Following is a paradigmatic table of the transitive verb in the present tense:

sētē'n, to see.

Object	Subject, Singular		
	1st Person	2nd Person	3rd Person
Singular, 1st person	—	qat rī sētē'	qat wu sētē'n
" 2nd "	ī qa sētē'n	—	ī wu sētē'n
" 3rd "	qoa sētē'n	rī sētē'n	ac wu sētē'n
Plural 1st "	—	ha rī sētē'n	ha wu sētē'n
" 2nd "	rī qa sētē'n	—	rī wu sētē'n
" 3rd "	has qoa sētē'n	has rī sētē'n	hōtc wu sētē'n

Object	Subject, Plural		
	1st Person	2nd Person	3rd Person
Singular, 1st person	—	qat rīrī sētē'n	has qat wu sētē'n
" 2nd "	ī wu tu sētē'n	—	has ī wu sētē'n
" 3rd "	wu tu sētē'n	rīrī sētē'n	has ac wu sētē'n
Plural, 1st "	—	ha rīrī sētē'n	has ha wu sētē'n
" 2nd "	rī wu tu sētē'n	—	has rī wu sētē'n
" 3rd "	has wu tu sētē'n	has rīrī sētē'n	—

When the object is a substantive it precedes the subject:

hīn qa tana', I drink water. *hīn a tana'*, he drinks water.

NOTE.—In a great number of cases the first person singular of the transitive verb is *qoa* instead of *qa*. I am not quite certain how this form originates, but it seems to be a contraction of *qa wu* or of *qa wa*. It would seem that the third person—subject as well as object—takes this particle, and this would explain the *qoa* in *qoa sētē'n*, he sees him. In certain cases it is evidently contracted from *qa ra*, as in the perfect. I am, however, far from being able to explain the rules regulating the use of *qoa* and *qa*.

at qoa qa, I have eaten (from *at qara qa*).
goa sētē'n, I see him.
qoa sētē'nēn, I have seen it once.
goa a'qēn, I have heard it once, occasionally.
ī ēctat k·u qoa a'qēn, I have heard of your father (somebody spoke of him).
dē k·ug· qoa gōd, I am going to go.
at k·ug· qoa qa, I shall eat.
na tlī rē dē k·ug· qoa tēn, I am going far away.
k·ānt qoa nuk, I am angry.

at qa qa, I am eating.
qa tē'nēn, I have seen it frequently.
qa tlītē'n, I look at it.
qa a'qtcēn, I have heard it often, I know it.
ī ē'ctat qa a'qtcēn, I have heard of your father (he is widely known).
qat k·ug· qa gōd, I (emphatically) am going to go.

The character of the past is—*gūn*,-*g·ēn*, or -*ēn*, according to the terminal sound of the verb. The tense formed by this suffix corresponds to both our imperfect and perfect:

ī qa sētē'n-ēn, I saw you just now.
(*dē*) *qa gōd-ē'n*, I went.
qoa a'q-ēn, I heard it (once, occasionally).
qa a'qtc-ēn, I have heard it (frequently).
ī anē' qoa sētē'n-ēn, I have seen your country (once).

ī anē qa tēn'-ēn, I have seen your country (often).
hin qa tanā'-g·ēn, I was drinking (water).
ara kāwa dan-ē'n a'sē, it has been snowing.
dāg wu stā'n-ēn, it has been raining.
ā wu dāg gan-ē'n, the sun was shining.

Besides this, I found the following perfect forms:

atc yē qa sīnē', I have done it.
(*dē ran*) *at qoa qa*, I have eaten.
(*dē*) *qa tana'*, I have drunk.

To eat, perfect.

Singular, 1st person, *at qoa qa*.		Plural, 1st person, *at wu to ra qa*.
„ 2nd „ *at ī ra qa*.		„ 2nd „ *at irī ra qa*.
„ 3rd „ *at wu ra qa*.		„ 3rd „ *has at wu ra qa*.

It seems that this form agrees with Wemiaminov's perfect tense. It must be stated that in many instances the imperfect characteristic is dropped, and that thus a form originates which is identical with the present tense. The inflexion of *aqtc*, to know, is of interest regarding this point.

Singular, 1st person, *qā aqtc*.	Plural, 1st person, *tō ra aqtc*.
„ 2nd „ *ī ra aqtc*.	„ 2nd „ *īrī ra aqtc*.
„ 3rd „ *a ra aqtc*.	„ 3rd „ *has a ra aqtc*.

This shows that the verb is evidently the perfect, I have heard, and *ra* appears to be the particle expressing a completed action (see p. 860).

The future tense is characterised by *k·ug·*, which is placed between the object and the subject.

at k·ug· qa tana', I am going to drink.
(*qat*) *k·ug· qa gōd*, I shall go.
k·ug· qoa aq, I shall hear it.
arc k·ug· ra dān, it is going to snow.
rē a k·ug· dag gān, the sun is going to shine.
yē k·ug· qoa sinē', I shall do it.
(*dē*) *k·ug· qoa gōd*, I shall go.
k·ug· qoa tēn, I shall leave.
dag k·ug· sētā'n, it is going to rain.

To eat, future.

Singular, 1st person, *at k·ug· qa qa'*	Plural, 1st person, *at k·ug· tō qa* (*gE*).
„ 2nd „ *at k·ag· ī qa* (*gE*).	„ 2nd „ *at k·ug· rī qa* (*gE*).
„ 3rd „ *at k·ug· qa* (*gE*).	„ 3rd „ *has at k·ug· a qa*.

To see, future.

	I shall see.	You will see.
me	—	(*rc*) *qat k·úg· rī sētē'n*.
you	(*rc*) *ī k·'qoa sētē'n*.	—
him	(*rē*) *k·'qa sētē'n*.	(*rc*) *k·' rī sētē'n*.
us	—	(*rē*) *ha k·' rī sētē'n*.
you	(*rc*) *rī k·'qoa sētē'n*.	—
them	(*rc*) *has k·'qoa sētē'n*.	(*rē*) *has k·ag· rī sētē'n*.

It seems that *k·ug·* is sometimes abbreviated, and in other instances asssumes the form *k·ag·*. The initial *rē* is not necessary for forming the plural. *Kyē* (see p. 861) is very frequently used in connection with future forms.

Interrogative.

The interrogative is formed by the particle *agE*, which is attached to the verb, but in case the latter is accompanied by an adverb it follows the latter.

Intransitive Verb.

To be sick, present.

Singular, 1st person, *qat ra nēk' agE?*	Plural, 1st person, *ha ra nēk' agE?*
„ 2nd „ *ī ra nēk' agE?*	„ 2nd „ *rī ra nēk' agE?*
„ 3rd *ra nēk' agE?*	„ 3rd „ *has ra nēk' agE?*

Imperfect.

qat nē'gun agᴇ? was I sick? &c.

Future.

(*kyē*) *qat k·ug· ra nēk' agᴇ?* am I going to be sick?

TRANSITIVE VERB.

qat rī sētē'n agᴇ? do you see me? *ha ri sētē'n agᴇ?* do you see us?
rī sētē'n agᴇ(s)? do you see him? *has ri sētē'n agᴇ?* do you see them?

Imperfect.

(*dē*) *qat rī sētēnē'n agᴇ?* did you see me?
dē rī sētēnē'n agᴇ? or *rī sētēnē'n agᴇs?* did you see him?
ha rī sētēnē'n agᴇ? did you see us?

Here are a few instances in which *agᴇ* follows the adverb:

sērē'nk agᴇ rī ha k·ug· rī sētē'n? will you see us to-morrow?
tᴇtgᴇ' agᴇ rī sētē'n? did you see him yesterday?
Also: *aq hitī agᴇ' rᴇ k'ᴇ'?* is my house all right?

In interrogative sentences *agᴇ* stands for our *verbum substantivum* (see p. 69).

aq ari agᴇ? is that mine? *aq hiti agᴇ?* is that my house?

In order to emphasise the question, it may be repeated in the beginning of the sentence:

agᴇ aq hiti agᴇ? is that my house?

After an interrogative pronoun the interrogative particle is not used:

tāse ī djunēn? what did you dream?

IMPERATIVE.

I found two forms of imperative; one formed by the suffix *-dᴇ*, the other by *k·a*:

-dᴇ:	*at qadᴇ'!* eat!	*cēndᴇ'!* get up!
	at īrī qadᴇ'! eat! (plural)	—
k·a:	*k·a sētē'n!* look here!	*qat k·a sētē'n!* look at me!
	—	*k·a sētē'n!* look at him!
	—	*ha k·a sētē'n!* look at us!
	—	*has k·a sētē'n!* look at them!
	a k·aq sētē'n! let him look!	*qat a k·aq sētē'n!* let him look at me!
	—	*rī k·a tu tlitē'n!* let us look at you!
	yē k·a sinē'! do it!	*a dē k·a sia'q!* listen now!
	k·a snēq! save him!	*at k·a tō qa!* let us eat!
	qat k·a snēq! save me!	

Both forms are in some instances combined:

at k·a gadᴇ'! let him eat! *at k·a t gadᴇ'!* let us eat!

The following forms are doubtful:

suqs'ēt'ᴇ'n! think of it! *hāt'ētlk'ē'n!* look here!

CONDITIONAL.

The conditional has the suffix *-nēk·'*. It will be seen from the following examples that the verbs frequently take the particle *na* in this mood. This agrees well with our supposition that the latter denotes the commencement of a state.

dūg sētannēk·', *tlētl ha dē k·ug· wa gōd*, if it rains, I shall not come.
aq dūg gannēk·', *ha dē k·ug· wa gōd*, if the sun shines, I shall come.
gᴇ nēk'nēk·', *tlētl a k·ug· atlē'q*, if he is sick, I shall not dance.
qat gᴇ nēk'nēk·', if I am sick, ...
qat ran hanēk·', if I am hungry, ...
ī qa sētē'nnēk·', if I see you, ...
tl' ī qoa sētē'nnēk·', if I do not see you, ...
tl' qoa sētē'nnēk·', if I do not see him, ...
tc·ᴇtlᴇ'k i qa tē'nēk·', every time I see you, ...

The following are constructed with *na*:

> *aq īc na nā'nēk'*, *tlētl a k·ug· atlēq*, if my father dies, I shall not dance.
> *k·unatē'nnēk'*, *aq tōru kyē k·ug· wu nēk'*, if he leaves, my mind will be sick.
> *k·unītē'nnēk'*, if you should leave.
> *tl* (1) *aq* (2) *īc* (3) *ue wu na* (4), *runōn katlēqē'n* (5), if (4) my (2) father (3) were not (1) dead (4), I should dance (5).

Negative.

The negative is formed by *tlētl*, not. The negative has always the particle *wu*.

> *tlētl qat wu nēk'*, I am not sick.
> *tlētl qat wu nēgun*, I have not been sick.

In the interrogative negative the interrogative particle follows the negative, and both are contracted into *tlēgītl*:

> *tlēgītl qat wu nēk'?* am I not sick?
> *tlēgītl kyē qat k·ug· wu nēk'?* am I not going to be sick?

Imperative Negative.

tlētl at i qak·! don't eat! *tlētl at rī qak·!* don't eat! (plural)
tlētl at tō qak·! let us not eat!

Derivatives.

Undoubtedly there exist a considerable number of derivatives in Tlingit. It seems probable that the majority of these derivatives are formed by means of particles. I shall first give a few examples of the use of these particles, and the change they effect in the meaning of the verb:

rE nēk', he (present) is sick.
wu nēk', he (absent) is sick; he is growing sick.
(*tc*'E)*ck·'a qa tlī nēk'*, I pretend to be sick.
ck·'a qa tlī qa, I pretend to eat.
rE dEtl, heavy.
tlētl wu dEtl, not heavy.
kū dEtl, heavy (referring to man).

The following seem to be derivatives in the proper meaning of that term:

sē-	*tēn*, to look;	*sētē'n*, to see.
	aq, to hear;	*sēa'q*, to listen.
tlī-	*tēn*, to see;	*qa tlītē'n*, I look at it.
-tc	*aq*, to hear;	*aqtc*, to know.
	nēk', sick;	*nēk'tc*, to be sick a long time.

There are some sentences that seem to indicate the existence of a dubitative formed by means of the interrogative particle:

gutl (1) *Ts'ōtsQE'n* (2) *agE* (3) *woE'* (4), may be (1, 3) you (4) are a Tsimshian (2);

But the same may be expressed simply with *gutl*:

> *gutl* (1) *Ts'ōtsQE'n* (2) *woE'* (3), may be (1) you (3) are a Tsimshian (2).
> *gutl* (1) *qat* (2) *wu nēk'* (3), may be (1) I (2) am sick (3).

The passive seems to be formed by means of the particle *wu* and the stem:

> *qat wu nēq*, I am saved; but this appears doubtful, as the active form, *sīnē'q*, to save, may be compound and mean: to make saved.

Note.—A circumscriptive inflexion of the verb is very frequent. It is formed by using the word (my, your, his) 'mind' instead of the pronoun:

> *aq tōru rE k'E'*, I am glad = my mind is good.
> *aq torū sigō at qa*, I wish to eat = my mind desires to eat.

Verbum Substantivum.

It was mentioned above that the particle *yē* may have the meaning of the *verbum substantivum*. Undoubtedly the demonstrative *a* is frequently used in this way:

hīt a tlēna, that is a large house. *ī hīti asia*, that is your house.

The independent pronoun stands also for the pronoun and *verbum substantivum*:

qat, it is I. *Tlingit woE'*, you are a Tlingit.

THE ADVERB.

The adverb stands mostly at the beginning of the sentence:

> *yāridᴇt has rī sētē'n*, you see them now.
> *rᴇsū' qat wu nēk'*, I just got sick.
> *tᴇtgᴇ' agᴇ' ri sētē'n?* did you see him yesterday?
> *tlīts'ē aq ā'nē k·ug· rī sētē'n*, later on you will see my country.

In a few cases it stands at the end of the sentence:

> *qat* (1) *k·anickidēq* (2) *sitē'* (3), I am (1) very (3) poor (2).

FORMATION OF WORDS.

It was mentioned above that compound words are very frequent, and I believe that all words can be reduced to monosyllabic stems. In many cases it is evident that the word is a compound, although we are not able to determine the meaning of the elements. Excepting the particles referred to above (p. 860), it seems that the composing elements may occur independently as well as forming part of other words. For instance, *riā'ti*, place for something, occurs both independently and as a constituent of many words:

> *t'ēk'a riā'ti*, mortar = pestle place. *k·'oā'tl riā'ti*, bed = feather place.

From the same stem are derived the following:

> *ya'k'rᴇrē't*, canoe place.
> *kaqᴇ'guarē't*, mortar = pestle place.
> *tōuqsᴇrē't*, whistle = place into which one blows.
> *gutsrē(t)*, heaven = cloud place.
> *g·an ētē'*, fire place.
> *tl'ēnētē'*, beach = sand place.

Many adjectives are compounds of *tlē(tl)*, being merely a negation of their opposite:

> *tlētl wu ck'ᴇ*, bad, and *tl'wu ck'ᴇ*, ugly. *tlētl wu tlītsēn*, weak.
> *tlētl wu dᴇtl*, light.

Probably also:

> *ku watl*, short (see *ku wat*, long). *tlk·atck*, lame.
> *tk·ōctēn*, blind (*tēn*, to see). *tlk·ōtl'aqt*, deaf (*aq*, to hear).

I give finally a collection of sentences:

> *hahēa qa tana'!* give me to drink!
> *a ku qa tli qētl*, I am afraid.
> *aqag·a k·aqcēʜi't*, I paint my face.
> *aq ēk·' iē'rētē qun*, I am and remain thin.
> *at qa qa rīt aq tōrū tē*, I want to eat.
> *at qa agᴇ ī tōrū sīgō'?* do you wish to eat?
> *aq torū sīgō' at qa*, I wish to eat.
> *aq tōru wa sigō' at qoa qū rit*, I wish to eat.
> *tlētl aq tōru wa wu sīgō' qat wu nēk'*, I do not like to be sick.
> *gācu dē qat wu nē'qēk'*, I should like to be well.
> *gācu (woᴇ') rī gōd (yua')*, I wish you would go.
> *gācu dē qa gōd*, I wish to go.
> *gacū' tlingit k·'a qa aqtc*, I wish I understood the Tlingit.
> *qa cᴇgōk rāndat'ᴇ'tc*, I can swim.
> *tlētl wu qa cᴇgōk rāndat'ᴇ'tc*, I cannot swim.
> *tlētl a dē at qoa qa rīrē*, I cannot eat.
> *tcātl kyēwu qa sī'yik·*, I haul in halibut (halibut line I haul in).
> *hītk·tō rc qoa gōd*, I go to the houses.
> *hītk·tō re a nē gōd*, he goes to the houses.
> *tlētl ī tla tl'ᴇk· qēk'!* don't make it wet!
> *rᴇ tli tlᴇ'k·!* don't make it wet!
> (*tc'ᴇ*) *ck·'a qa tlī nēk'*, I pretend to be sick.
> *ck·'a qa tli qa*, I pretend to eat.
> *Ts'ōtsqᴇ'nqc qa tlīē'q*, I pretend to be a Tsimshian.

Ts'ōtsQE'n agE wū, hē tlētl tlaqōsēkō', maybe he is a Tsimshian, but I do not know.
tlētl ta qoakō qat nēk', I fear I am sick (I am not sure I am sick).
gutl hōtc yē awu sinē, maybe he has done it.
wē atqa qat sī nēk', that food makes me sick.
qat k·asnēq ! kitc' anag·ā't k·ō yēk' ! save me, O rainbow !
wōtc qat wu sēnē'q ! It is he who saved me !
ara ka wa dan, it is snowing.
ara ka wa danēn a'sē, it has been snowing.
ara k·ug· wa dan, it is going to snow.
tlētl qat ca cqawu ! no hair is on my head.
aq k'ōs tāk rE nēk', my foot is sore.
su q· s'ēt'E'n, I think of him.
ī su q s'ēt'E'n, I think of you.
wūctē'n at tō ta qa, we eat together.
c'ītlk'E'tl, stop crying !
wutc kikE't has ta k·ēn, they sit opposite each other.
John es kikE't qaa', John is opposite to me.
wutcē'n ānka dē kaq to ā't, we go together to the town.
wutcē'n ānka dē sk·uqk·a ā't, they go together to the town.
cEda hōtc yē anaq si'nē ! let him do it !
hīn qa rē k·ug· qoa te ! I am going to put you into the water.
hīn qa ī rE' qoa tē, I put your face into the water (I baptise you).

It will be seen from these remarks and examples how much remains to be done in this language. It is evident that the grammatical structure cannot be understood until the words have been more closely studied and we know the meaning of their components and of the particles which are so important in the inflexion of the verb. From what we know, it appears that the particles and pronouns are placed between the components of words. I do not think there is a real infixion. The independence which the components retain is one of the most remarkable features of this language.

II. Haida.

Obtained from Wīha, a native of Skidegate (Tlk·a gyitl), and Mrs. Franklin, a half-blood Indian, living in Victoria.

PHONETICS.

Vowels: a, (â), e, E, ī, ō, u.
Consonants: d, t; gy, ky; g, k, k'; g·, k·; r, q; h, H, y; m, n, ñ; w; s, (dz), ts; c, dj, tc; l, dl, tl.

There is only one labial, *m*, which does not occur as an initial sound except in a few words which are borrowed from the Tsimshian. The *m* is not the pure English *m*, but closely related to *ñ*, from which it is distinguished with great difficulty, the lips being not perfectly closed. The difference between surds and sonants is still slighter than in Tlingit, it being in most cases impossible to determine whether a sound is the one or the other. I believe a thorough study of the language would show that it would be proper to use only one letter for the dentals and one for the gutturals, the slight variations of which cause in our ear the sensation of surds and sonants. The *r* is very guttural, but has more of a trill than in Tlingit. Therefore it is easily distinguished from the *w*. The hiatus is very frequent, and occurs after all consonants. In the beginning of words I found the following combinations of consonants: *l*, *dl*, *tl*, followed by a guttural, and *t*, *ñ*, followed by *g* (one instance); *s* followed by any consonant, except *s*, *dz*, *ts*, *c*, *dj*, *tc*. Regarding the latter, it must be stated that *s* frequently does not belong to the stem; *t* is followed by *h*. I found the following combinations of consonants terminating words:

				ks			
		nq		ns		ndl	ntl
sk	sk·				st		stl
tsk					ct		
tk							
tlk	tlk·		ln				

All letters can be initial and terminal sounds. (Regarding *m* see above.) Combinations of consonants are very rare.

GRAMMATICAL NOTES.

THE NOUN.

The Haida language has no grammatical sex, and no separate forms for singular and plural. When it is necessary or desirable to state expressly that the plural is meant, *skōl* (a group of) is added when human beings are referred to; *k·oa'n* in all other cases. The latter may also be applied to human beings.

djā'ata skōl, women.
ētl skōlga, it is we.
ētl gyitina skōl yuᴇ'nga, we belong to the eagle gens.
qā'ctqa skōl yūa'n, many people; but also—

ts'ᴇñ k·oa'n, beavers.
k·'ēt k·oa'n, trees.
na k·oan, houses.
qā'etqa k·oan yū'an, many people.

I have not found any indication of cases. Compound nouns are as frequent as they are in the Tlingit language, and they are composed in the same way, the components being placed side by side:

gy'atl d'amᴇ'l, ankle = leg knuckle.
gy'atl gya, dancing leggings = leg ornament.
tlkyan k·ā'itla, wood dish.
Tlk·a gyitl, stone beach, name of Skidegate village.
k·'ōtlta lrā'era, thief = steal master.
sqā'na dā'tzᴇñ, hat with carving of *Delphinus orca*.

The following examples consist of three components:

g'at k·'al gyā'atk, deer-skin blanket.
qē'tlᴇñ g·aēūdā'o, pipe = mouth smoke box.
slā'gul k·ā'tsē k·'ēdā', carved spoon—spoon head figure.
ga ta tā'n, table = it eat instrument.

Local adverbs are frequently placed between the components of the word, which always retain their independence: *hī u'nsē g·ata'* = wing top white (name of a bird).

The names of several colours are evidently composed words: *gō tlratl*, blue; *gan tlratl*, yellow; *aqa tlratl*, many-coloured.

THE ADJECTIVE.

The adjective is placed after the substantive to which it belongs:

g·al yā'kō, midnight = night half.
ādl dzi'nda, oar = long paddle.
lā'na gᴇ'tsō, small town.
lā'na yū'an, large town.
ian tlratl, black cloud.
ta'ñga g·'ā'ga, salt = dry ocean.

The adjective is rarely used alone; if it has no noun to which it belongs, *gyina*, something, is added:

gyina g·ada, something white.
gyina dā'ranga, something bad.
gyina k·a'lra, something different, another.

NUMERALS.

Cardinal Numbers.

1, *squn, sqa'sgō, sqoā'nsᴇñ*.
2, *stīñ*.
3, *dlk·u'nutl*.
4, *sta'nsᴇñ*.
5, *tlētl*.
6, *dlk·unō'utl*.
7, *dzi'gura*.
8, *sta'nsᴇñra*.
9, *tlālᴇñ sqoa'nsᴇñ*.
10, *tlā'atl*.
11, *tlā'atl woqē'*, or *sqoā'nsᴇñ*.
20, *lag·usqaa'nēgō*.
30, *tlā'lē dlk·u'nutl*.
40, *tlā'lē sta'nsᴇñ*.
50, *tlā'lē tlē'etl*.
60, *tlā'lē dlk·unō'utl*.
70, *tlā'lē dzi'gura*.
80, *tlā'lē sta'nsᴇñra*.
90, *tlā'lē tlā'lᴇñ sqoā'nsᴇñgō*.
100, *lā'gua tlā'atl*.
200, *lā'gua stīñ*.
300, *lā'gua dlk·u'nutl*.
900, *lā'gua tlā'lᴇñ sqoā'nsᴇñgō*.
1,000, *lā'gua tlā'lē tlā'atlē*.

Evidently four is second two, six the second three, eight the second four, and five and ten are also derived from the same stem, perhaps (*s*)*tl*, hand. The formation of four corresponds to that of the same number in Tlingit (see p. 857). I found no double forms of numerals, except for one: *sqoā'nsᴇñ* is the word generally used; *sqa'sgō* is used in counting divisions of time:

> *tā'da sqa'sgō*, one year.
> *g·al sqa'sgō*, one night.
> *sᴇn sqa'sgō*, one day, also all day long.

In counting objects classifying words are used very extensively:

> *na thēi stīñ*, two (sleep) houses.
> *thē'idān g·a sqoā'nsᴇñ*, one (flat) bed.
> *thē'idān tlg·a sqoā'nsᴇñ*, one (frame) bed.
> *k·ā'itla k·a stiñ*, two (open) dishes.
> *tlō k·a stiñ*, two (open) canoes.
> *tlō gi stīñ*, two (?) canoes.
> *tlk·a g·ā'is sqoā'nsᴇñ*, one (round) stone.
> *k·'ēi stiñ*, steamboat, two (ship) steamboats.
> *tlk·ē'it sta sqoā'nsᴇñ*, one (?) bow.
> *k·'ēt sk·a sqoā'nsᴇñ*, one (long) tree.
> *gatatā'n tlga sqoā'nsᴇñ*, one (with legs) table.

No such classifying words are used in counting animals and divisions of time. I am unable to account for the following double form:

$$\left.\begin{array}{l}\textit{ē'tlᴇñga stīñ}\\ \textit{ētlᴇnstat stiñ}\end{array}\right\}\text{two men.}$$

Ordinal Numbers.

The following ordinal numbers seem to me very doubtful:

dēkuna'ct, the first.
dētlā'a, the second.
lāwagō'st, the third.
lātlalā'nā, the fourth.
lāwa gōstlā'na, the fifth.

So far as I was able to discover, the cardinal numbers are generally used in place of ordinal numbers.

Numeral Adverbs.

The numeral adverbs are formed by adding the suffix *-gᴇn* to the cardinal numbers.

sqoā'nsᴇñgᴇn, once.
stī'ñgᴇn, twice.

Distributive Numbers.

These are also expressed by the cardinal numbers. For 'one' the form *squn* is used:

> *squn qaula'ñ tla ēsta g·ō'ganē*, I give one to each.
> *stīñ qaula'ñ tla ēsta g·o'ganē*, I give two to each.

THE PRONOUN.

Personal Pronoun.

There are two forms of the personal pronoun exactly alike in character to those found in Tlingit: the former denoting simply the person, the second denoting that the person is one among many. In Haida the latter is used for inflecting the transitive verb, the former for inflecting the intransitive verb. The objective case of the pronoun is the same as the intransitive pronoun. This would make it probable that the intransitive verb is indeed impersonal, if it were not for the fact that the same form is used for the ordinary pronoun.

Personal Pronoun.

—	Ordinary	Selective	Intransitive	Transitive	
				Subjective	Objective
Singular, 1st person	dēa	tlā'a	dē	tla, tl	dē
„ 2nd „	dᴇ'ña	dā'a	dᴇñ	da	dᴇñ
„ 3rd „	lā'a	lā'a	la	la, l	la
Plural, 1st person	ē'tla	d'alᴇ'ñga	ētl	d'alᴇ'ñ	ētl
„ 2nd „	dalᴇ'ñga	dalᴇ'ñga	dālᴇ'ñ	dālᴇ'ñ	dālᴇ'ñ
„ 3rd „	lā'a	ā'a	la	la, l	la

Note 1.—The *a* at the end of the ordinary and selective forms is the same *a* which is affixed to all words when used independently, and also in other cases where it seems to stand merely for reasons of euphony.

Note 2.—The *a* at the end of *tla* and *la*, when the subject of transitive verbs, seems to be frequently dropped, or at least to be pronounced very indistinctly.

Demonstrative Pronoun.

There are a number of words which take the place of demonstrative pronouns, which, however, seem to be compounds. I have not referred to the use of an article, as it seems to be really the demonstrative pronoun. It is *n* or *nᴇñ*. Here are a few examples:

n dj'ā'ata, a woman.
n sqā'g·a, a shaman.
nᴇñ ē'tlcñga, a man.
nᴇñ g·ā'qa, a baby.
nᴇñ sqoa'nsᴇñ, one man.

The last example is suggestive of the origin of this article, which, however, is very seldom used.

This article, combined with *ēts*, then forms the demonstrative which is most frequently used: *nēts*, to which the terminal *a* is frequently added: *nē'tsa*. To this a prefix *a*, of unknown origin, is frequently added: *anē'tsa*. These three forms mean 'this'; *wa* (denoting distance) prefixed makes them 'that.'

anēts nārau ē'tsi, this is his house, it is this man's house.
wanēts nārau ē'tsi, this is his house, it is that man's house.

We also find *nᴇñ*, with and without the prefix *a*, used in this sense:

a nᴇñ dj'ā'atas nā'rau ē'tsi, it is this woman's house.

I find besides this the plural form *stlda* and *astlda*, and *tsk·a'ē* for 'these,' which I am unable to explain.

Note.—The prefix *a* occurs also in temporal adverbs and with the personal pronoun, third person:

a-tlsta, some time ago.
a-la ē'tsisgua da k·iñ? do you see him?
a-uwiā't, now.
a-dā'rgatl, yesterday.

Note.—The use of *wa* as denoting distance will best be seen from the following examples:

wa tlō'qcn, all (distant).
wa t'ᴇl skōl, many people (distant).
wa la ē'tsisgua da k·iñ? do you see him there?
wa nāra tlgai ē'tsisgua da k·iñ? do you see my land there?
gyīstō wa ē'tsᴇñ? who is that?
watcgua gyina ē'tsisgua da k·iñ? do you see anything there?
wa nā ēts tla k·i'ñga, I see a house there.

Possessive Pronoun.

The possessive pronoun has various forms, the use of which is very difficult to understand. As the material which I have collected is not sufficient for a satisfactory explanation of the use of this pronoun, I must confine myself to giving examples of the various forms, illustrating their use.

The simplest form of the possessive pronoun is identical with the objective form of the personal pronoun. It precedes the substantive, to which is added the suffix *ra*:

Singular, 1st person,	*dē—ra.*		Plural, 1st person,	*ētl—ra.*
„ 2nd „	*dɛñ—ra.*		„ 2nd „	*dalɛñ—ra.*
„ 3rd „	*l—ra.*		„ 3rd „	*l—ra.*

dē k·uñ—ra, my father.

In certain compound words the elements are not simply placed side by side, but the possessive form is used, corresponding to our genitive. This, however, seems to be the case only when the object is really possessed:

lā'na ā'ora, chief = town mother. *djā'ata qā'tra*, the woman's father.

The full form of the possessive pronoun in indicative sentences is:

Singular, 1st person,	*gyagɛn—gai*	Plural, 1st person,	*ētl gyā'ra—gai*
„ 2nd „	*dɛñ gyā'ra—gai*	„ 2nd „	*dalɛñ gyā'ra—gai*
„ 3rd „	*l gyā'ra—gai*	„ 3rd „	*l gyā'ra—gai*

Examples:

kua'ē gya'gɛn nāgai da k·i'ng·asga, later on you will see my house.
gya'gɛn nā'gai, it is my house.
dɛñ gyā'ra nā'gaigua ēts? is that your house?
gɛm gya'gen ē'tsranga, it is not mine.

The same form with the terminal vowel *ō* is used for the substantive possessive pronoun:

gya'genō, mine.	*ētl gyā'raō*, ours.
dɛñ gyā'raō, yours.	*dalɛ'ñ gyā'raō*, yours.
l gyā'raō, his.	*la gyā'raō*, theirs.

The second form of the possessive pronoun is the following:

Singular, 1st person,	*nā'ra—gai*	Plural, 1st person,	*ē'tlāra—gai*
„ 2nd „	*dɛñra—gai*	„ 2nd „	*dalɛñra—gai*
„ 3rd „	*lā'ra—gai*	„ 3rd „	*lāra—gai*

NOTE.—In one instance I found for the second person singular: *tlñra—gai*.

In some instances this second form and the first are used indiscriminately:

kua'ē gya'gen nāgai da k·i'ñg·asga
kua'ē nāra nāgai da k·i'ñg·asga } later on you will see my house.

In other cases the first form must not be used, but I did not succeed in discovering the rule. The second form serves also as a substantive possessive pronoun:

nā'ragua, is it mine?
nā'ragua la da k·iñ, do you see mine?
tlgaigua nāra da k·iñ, do you see my land?
la ra tla lā'ra ista! give his to him!
hala! dē gi nā'ra ista! give me mine!
dārgatl nāra nā'gai da k·i'ng·asga, to-morrow you will see my house.
gyīnū nā'ra ā'lai ē'tsɛñ? where is my paddle?

NOTE.—The suffix *-gai* is sometimes contracted with the substantive to which it is affixed:

tlwai for *tlōgai*, canoe. *tlgai* for *tlgogai*, country.
qatai for *qatgai*, father.

In addressing a person only the suffix *-gai* is used:

k·u'ñgai! my father! *dā'gai!* my younger brother!

In a few instances I found the suffix *-rao* used for expressing the relation of possession. It is evidently of the same origin as the second part of *gyā'raō* (see above).

gyīstō nā'raō ē'tsɛñ, whose house is that?
ā'nets nā'raō ē'tsi, it is his house.
wastlda k·unrao ē'tsi, that is their father.

NOTE.—I found a peculiar possessive form in a few sentences, which, it would seem, is used where object and subject are the same person:

k'alañ tl tlñga, I wash my skin.
qāñgañ la tlñga, he washes his face.
tlgañ k·a tl i'sg·asga, I shall go to my country.
tlgañ tl k·iñg·asga, I shall see my country.

THE VERB.

In discussing the pronoun we stated that there are two forms, one for the transitive, the other for the intransitive verb, the latter being identical with the objective case of the transitive pronoun. This makes it probable that the intransitive verb may be impersonal. The division of transitive and intransitive verbs is, of course, peculiar to the language, but it will be found very much like that observed in Tlingit. Following is a list of intransitive and transitive verbs in the first person singular:

INTRANSITIVE VERBS.

dē qā'etqaga, I am a Haida.
dē gyītinā'ga, I belong to the eagle gens.
dē st'ē'ga, I am sick.
dē lā'ga, I am well.
dē lgilga, I recover from sickness.
dē ñgaistlEñ, I recover from sickness.
dē k·'oē'ta, I am hungry.
dē k·'ā'dōga, I am thirsty.
dē stātlga, I like.
dē u'nsētga, I know to—
dē ran(?), I have.
dē k·'aēskidā'ga, I forget.

TRANSITIVE VERBS.

tla sk·agē'tlga, I cry.
tla Hia'tlga, I dance.
tla uā'ga, I eat with somebody.
tla ē'sta, I give.
tla k·ā'ga, I go.
tla dā'raga, I have.
tla gūdE'ñ, I hear.
tla tē'aqan, I kill.
tla k'ā'ga, I laugh.
tla qutlga, I drink.
tla ga taga, I eat (it).
tla g·ō'tlraga, I make.
tl k·iñga, I see.
tla k·'ā'ga (*tla thā'ga?*), I sleep.
tla skungudE'ngEn, I smell.
tla k'ē'tlkulga, I talk.
tla gū'dEn (see *dēgū'dEnra*), I think.
tl tlñga, I wash.

I found four tenses: the present, imperfect, perfect, and future; and five moods: the indicative, interrogative, negative, imperative, and infinitive. I have no examples of the conjunctive and conditional which make their use sufficiently clear. I shall first give the tenses of the intransitive verb in a paradigmatic form:

st'ē, sick.

—	Present tense	Imperfect	Perfect	Future[1]
Singular, 1st person	dē st'ē'ga	dē st'ē'gan	dē st'ē'ganē	dē st'ē'rasga
„ 2nd „	dEñ st'ē'gagEn	dEñ st'ē'gagan	dEñ st'ē'ganē	dEñ st'ē'rasga *and* st'ē'rasañ
„ 3rd „	l st'ē'ga	l st'ē'gan	l st'ē'ganē	l st'ē'rasga
Plural 1st „	ētl st'ē'ga	ētl st'ē'gan	ētl st'ē'ganē	ētl st'ē'rasga
„ 2nd „	dalE'ñ st'ē'gagEn	dalEñ st'ē'gagan	dalEñ st'ē'ganē	dalEñ st'ē'rasga *and* st'ē'rasañ
„ 3rd „	l st'ē'rōga	l st'ē'rōgan	l st'ērō'ganē	l st'ēg·uasga

In inflecting the transitive verb the pronoun is placed immediately before the verb. In some instances the verb has an indefinite object, *ga*, exactly corresponding to the same indefinite object in Tlingit (see p. 861). It is placed between the subject and the verb: *tla ga ta*, I eat it. As a rule, the object is placed before the subject, but when the object is a pronoun and has a separate objective form (1st, 2nd, person singular, 1st person plural) the sequence may be reversed. Following is a paradigmatic table of the transitive verb in the present tense:

[1] I found the following doubtful future: l st'ērañ k·acā'raga, he is going to be sick.

k·iñ, to see.

INDICATIVE; PRESENT TENSE.

Object	Subject, Singular		
	1st person	2nd person	3rd person
Singular, 1st person	—	dē da k·i'ñga	dē la k·iñga
„ 2nd „	dEñ tl k·iñga	—	dEñ la k·i'ñga
„ 3rd „	l tla k·iñga / tla l k·iñga	la da k·i'ñga	—
Plural, 1st „	—	ētl da k·i'ñga	ētl la k·i'ñga
„ 2nd „	dālEñ tl k·iñga	—	dalE'ñ la k·i'ñga
„ 3rd „	la tl k·iñrōga	la da k·i'ñrōga	—

Object	Subject, Plural		
	1st person	2nd person	3rd person
Singular, 1st person	—	dē dālEñ k·i'ñga	dē la k·i'ñrōga
„ 2nd „	d'alEñ dEñ k·i'ñga	—	dEñ la k·i'ñrōga
„ 3rd „	lE dEñ k·i'ñga	la dālEñ k·i'ñga	—
Plural, 1st „	—	ētl dalEñ k·i'ñga	ētl la k·i'ñrōga
„ 2nd „	dalEñ dEñ k·i'ñga	—	dalEñ la k·i'ñrōga
„ 3rd „	lE dEñ k·i'ñrōga	la dalEñ k·i'ñrōga	—

NOTE.—It seems that in the first person plural the transitive pronoun *d'alE'ñ* is contracted. It is remarkable that the characteristic suffix of the third person plural *-rō* is also used when the object is in the third person plural. When the object is a substantive it is placed before the subject:

tcī'nō tl tā'ga, I eat salmon.

It will be seen that the suffixes of the transitive verb are the same as those of the intransitive, with the sole exception of the second persons, where the termination *-gEn* is missing. This, however, is also frequently the case in intransitive verbs.

NOTE.—While in the great majority of cases the verb is inflected, as indicated above, I found a considerable number of instances in which the terminal *-ga* was missing; for instance, *tla gata'* and *tla gata'ga*, I eat; *tla gūdE'ñ*, I hear. In other cases I found the terminal syllable *-gEñ* instead of *-ga*; but I was not able to detect any rule regarding their use.

tla gatā'ñg ē'sEñ tla gata', I eat and eat again.
tla gudE'ñgEñ, I hear.
tla skuñgudE'ñgEñ, I smell.
tla k·iñgEñ, I see it (something inanimate).

NOTE.—There are a few instances in which the pronoun, second person singular, seems to be *tlñ* or *tlañ*:

da tlñ k·iñga, I see you. *tcīn tla tlañra ta!* eat your salmon!
tlñra nā'gai, your house.

NOTE.—Sometimes the syllable *gyī* is added to the first person without changing the meaning:

gyī dē stātl yūa'ngang, I should like much.
dEñ k·ea'ñgai gyīdē gudE'ñga, I wish to see you.
gyī dē k·'aē'skidā'ganē! I forgot!
hal dē gyī sqā'wai i'sta! give me a knife!

It may be that it is an interjection similar to 'oh!' (Latin *utinam!*)

INTERROGATIVE.

The interrogative is expressed by the particle *gua*, which is placed after the subject, object, or adverb, as the case may be.

INTRANSITIVE VERB.

Present Tense.

Singular, 1st person,	*dē gua st'ē?*	Plural, 1st person,	*ētl gua st'ē?*
„ 2nd „	*dEñ gua st'ēgōs?*	„ 2nd „	*dalE'ñ gua st'ē'gōs?*
„ 3rd „	*la gua st'ē'gōs?*	„ 3rd „	*la gua st'ē'rōā'ōs?*

Imperfect.

dē gua st'ē'ga? and *dē' gua st'ēgō'odja?* was I sick?

TRANSITIVE VERB.

dē gua da k·iñ? do you see me? *ētl gua k·iñ?* do you see us?
la gua da k·iñ? do you see him? *la gua da k·iñrō?* do you see them?
da gua da k·iñ? do you see it?

In the interrogative the subject frequently precedes the object:

dā gua qa dā'ra? have you got a dog?

When there is an adverb accompanying the verb the former takes the interrogative particle:

dā'rgatlgua dEñ st'ēgō'ōdja? were you sick yesterday?
a la ē'tsisgua da k·iñ? do you see them there?

It may also be attached to both object and adverb:

tlgaigua nā'ra da k·iñ? do you see my land?
watcgua gyina ē'tsisgua da k·iñ? do you see anything there (at a distance)?

Sentences beginning with interrogative words do not take this particle, and have instead of the verbal suffix *-ga*, *gEñ*:

gyī'stō st'ē'gEñ? who is sick?
gyī'stō ē'tsEñ? who is there?
gyī'stō nā'rao ē'tsEñ? whose house is that?
gō'su da tā'gEñ? what are you eating?
gō'su wa ē'tsEñ? what is that?
gō'gusg·anō da k'ā'gEñ? why do you laugh?
g·ā'tlentlā'ō gEm dē da k·iñgEñ ō'odja? why did not you see me?
k·asu'ñgu dEñ k·ē'tEñ? how are you?
dEñ gyā'ra nā'gai gua ēts? is that your house?
dEñ gyā'ra lā'nagai gua ēts Tlk·ā'gilta? is Tlk·agilt your town?

IMPERATIVE.

The second person singular is formed by the separable particle *tla*, which is affixed either to the verb or to its object, or precedes the verb. In the plural the suffix *-rō* is added to the stem of the verb:

Singular, 2nd person:	*tā tla!* eat!	and	*ga tla ta!* eat (it)!
	sqālE'n tla! sing!		*tla g·ō'tlga!* make it!
	k·ā'it tla! go!		*dzin da tla!* make it longer!
Plural, 2nd person:	*tā'rō tla!* eat!	and	*ga tla tā'rō.*
	qōtlrō tla! drink!		

In transitive verbs which have an object *tla* is always placed after the object:

dē tla k·iñ! look at me! *la tla k·iñ!* look at him!
ā'gEn tla k·iñ! look at yourself!
Plural, 1st person: *d'ā'lEñ ga tā s'añ!* let us eat!

A periphrastic form is frequently used:

hala! ga ta! come! eat!
hala! dē ē'tlwa! come! help me!
hala! gandl dē qotl da! come! make me drink water! (let me drink!)
hala! d'alEñ qotl s'añ! come! let us drink!

The following forms seem to indicate that there is still another method of forming the imperative:

nā'ra i'sta! give me mine! *qotl ta!* drink!

INFINITIVE.

I found two infinitives, one ending in *-(g)ai*, the other in *-g·an*.

gEm tl k'ag·ai dziñra'ñga, I laugh almost (I am not far from laughing).
dē g·uñra g'ōtulā'i gā'ustlō tl niātltlñā'ga, if my father were not dead, I should dance.
dEñ kcā'ñgai gyē dē statl yūa'ngEn, I should like much to see you.
sqala'ñg·an dē u'nsēt yū'anga, I understand well to sing.
rā'nitltag·an lu'nsēda, he knows to fight.

NOTE.—I give the following conditional sentences without an attempt at explanation:

l (1) *st'ē'gEs* (2) *rā'ganō* (3) *gEm* (4) *tl* (5) *k·āitlra'nga* (6), if (3) he (1) is sick (2), I (5) not (4) shall go (6).
dē (1) *k·u'ñra* (2) *gEm* (3) *g'ōt'utl* (4) *gEñ gyan* (5) *nia'tlrasga* (6), if (5) my (1) father (2) not (3) dead (4), I shall dance (6).
dē (1) *k·u'ñra* (2) *gōt'utl* (3) *gyan* (4) *gEm* (5) *tl* (6) *niatlrā'nsga* (7), if (4) my (1) father (2) dead (3), I (6) shall not (5) dance (7).
l (1) *st'ē'gē* (2) *gā'ustlō* (3) *lā'ra* (4) *tl* (5) *k·ā'itsgīga* (6), if not (3) he (1) were sick (2), I (5) should go (6) to him (4).
l (1) *st'ē'gē* (2) *gā'ustlō* (3) *dE'ñg'Et* (4) *lāra* (5) *tl* (6) *k·ā'itlñā'ga* (7), if not (3) he (1) were sick (2), I (6) should go (7) with you (4) to him (5).
dē (1) *k·u'ñra* (2) *g'ōtulai* (3) *gā'ustlō* (4) *tl* (5) *niatltlñā'gā* (6), if not (4) my (1) father (2) dead (3), I (5) should dance (6).

NEGATIVE.

The negative is formed by *gEm*, not, while the suffix *-ran* is added to the stem of the verb:

gEm dē st'ē'ranga, I am not sick.
gEm la tl k·iñranrōga, I do not see them.
gEm na ēs tl k·iñranga, I do not see a house there.

In the interrogative-negative the interrogative particle is attached to the negation; the suffix of the verb is *-rañ*.

gEm gua l st'ē'rañ? is he not sick?
gEm gua wa nā ēts da k·iñrañ? don't you see that house there?

Here is a negative imperative:

gEm tā'ranga! don't eat!

DERIVATIVES.

-gēi, repeatedly:
dē st'ē-gē'iga, I am repeatedly sick.

-gī(gEñ), he is in the habit of:
l k'a-gī'gEñga, he laughs always.
l rā'nitlta-gī'gEñga, he is in the habit of fighting.
tla gatagī'ga, I eat always.

-gil (gEñ) gītlEñ, it is beginning, growing to be:
dē st'ē'-gitlEñga, I am getting worse.
sEn-gītlEñga, dawn, it becomes daylight.
skuāga-gi'lgEñ, it is high water.
g'āisgō-gi'lga, it is growing round.
t'atsēgi'lga, the wind is increasing in strength.

gyiñ, to cause:
gyina (1) *tl* (2) *tā'gen* (3) *dē* (4) *gyiñ* (5) *st'ē'ga* (6), I (2) ate (3) something (1) (that) makes (5) me (4) sick (6).

There are several derivatives the meaning of which I do not know:

tl ta-nō'ga, I eat.
ag·alqua, it begins to be night.
k·cā'nga, to see (from *k·iñ*).

Verbum Substantivum.

ēts, there, and its derivations frequently stand for the *verbum substantivum*, as will be seen from the following examples. In such cases a terminal *-ō* is generally added to the subject:

tlk·ā'-ō ē'tsi, it is a rock, these are rocks.
g'at-ō ē'tsi, it is a deer.
tlā-ō ē'tsi, it is I.
dā gua ēts? is that you?
gya'gEn tlwai-ō ē'tsi, it is my canoe.
Qā'ēdes tlgā'ra-ō' ē'tsi, it is the country of the Haida.
wā'nets nā'rau-ō ē'tsi, it is his house.
la gyā'ra-ō ē'tsrōga, it is theirs.
gEm gya'gEn ē'tsranga, it is not mine.
gEm gya'gEn nā'gai ē'tsranga, it is not my house.

The Adverb.

It seems that adverbs are placed either at the beginning or at the end of a sentence:

dā'rgatl dē da k·iñgena, I saw you yesterday.
k'oā'ē lā'ra tlgai ta k·iñgasañ, you will see my land later on.
dā gudE'ñg·asEñ k'oā'ē, you will hear it later on.
tla l k·ea'ñgen sqoā'ntsEñgEn, I saw him once.
dārgatl īsEñ ētl da k·iñrasga, you will see us again to-morrow.
d'alE'ñ ā'sEñ gūdE'ñganē, we have heard it again.

Note.—In a number of instances I found the verbal affixes *-ga* and *-gEñ* not attached to the verb, but to the adverb, so that the latter would appear to be the inflected verb, if it were not for the fact that the pronoun precedes the verb. All the examples I collected refer to the adverb *yū'an*, much, very.

sqala'ñg·an dē u'nsēd yū'Enga, I know well to sing.
ētl gyitina skōl yū'Enga, we belong to the eagle gens.
dē ran na k·oan yū'Eñga, I have many houses.
dEñ k·eā'ngaige dē stātl yū'EñgEn, I should like much to see you.

FORMATION OF WORDS.

It was mentioned above that compound words occur very frequently, and it seems probable that by far the greater number of words are compounds of monosyllabic stems. In many cases I am unable to ascertain the meaning of the elements of words, although the fact that they are compounds cannot be doubted.

st'a k·a ran, plant of foot (perhaps: foot inside above).

sl k·a ran, palm of hand.
k·ulō k·a ran, knee pan.
k·ō'yē k·a ran, sky above.
na k·a ran, roof = house above.

Hi (1) *k'ōl* (2) *da'ñgō* (3), wrist [(arm (1) joint (2) ? (3)].
gy'atl (1) *k'ol* (2) *da'ñgō* (3), knee joint [(leg (1) joint (2) ? (3)].

k'ōts g·a'ñgō, post supporting roof.
Hī ta g·a'ñgō, rattle (*hi* probably arm).

gyā'rañ, to stand.
rāHitlta, to fight.
qoā'tlta, to boil.
k·ā'rañ, to walk.
k·'ō'tlta, to steal.

The word *k·ā'tsē*, head, appears in compounds generally in the form *k·ās*.

k·ās k·ē'tEl, head hair.
k·ās ku'tsē, head bone, skull.

The words denoting the activity of senses are evidently derived from the names of the respective organs:

	gyū, ear.	*gūdE'ñ*,[1] to hear.
	qañ, eye.	*k·iñ*, to see (I was frequently doubtful whether to write *k·iñ* or *qiñ*, but preferred the former, as I found it more frequently the more adequate spelling than *qiñ*).
	kun, nose.	*sku'ngudEñ*,[1] to smell.
Also:	*gūdEñ*, mind.	*gūdEñ*, to think.

In the word 'to smell' we find an initial *s*, which seems to occur rather often. There are some indications that it is interchangeable with *tl*.

sk·ātl and *tlk·ātl*, black.
k·as'E'ntsEñ and *k·atlE'ntsEñ*, brain.
sqēt and *qēt*, fire.

Finally I give a collection of sentences illustrating various peculiarities of the language:

nEñ k·'El g·adā'a, he is a white man.
dEñ tl k·iñgEn nEn k·'El g·ā'das, I see you are a white man.
tla nEñ dā'raga, I have one.
dē ran na k·oan yū'Eñga, I have many houses.
(*ātlran*) *na thēi stīñ tl dā'raga*, I have two houses.
wa t'El skōlga, there are many people.
tlgañ k·a tl i'sg·asga, I shall go to my country.
dē atgua da i'sqas? do you go with me?
squn qaulE'ñ lēistla g·ō'ganē, I give one to each.
l sk·al gyidā'ga, his shoulder is tattooed.
dEñgua gin qā'ētran? what is your people?
tlā'o tl g·ōtlra'ganē, I have made it myself.
dē gūdE'ñgai st'ē yū'an, I am downcast = my heart is very sick.
dEñ gua gyūqē'l? have you a perforation of your ear?
tl gū'den stlō dē st'ē'ga, I think I am sick.
dē nak·tl k·ōtltā'ēa'ganē, somebody has stolen mine (this form seems to serve for the passive).
dā g·ōtlran agEn st'ēda, you make yourself sick.
ha'ldēgi sqā'wai ista! give me a knife!
haldigi nā'ra sqā'wai digi i'sta! give me my knife!
hala dē'itk·a k·ā'it! come along with me!
gyi'stō tlrutlrā'ean? who made that?
gōt'El skōl yū'an, there are many people.

III. Tsimshian.

Obtained from a native of Meqtlak·qā'tla, 'Matthias'; a native of Ft. Simpson, Mrs. Lawson; and from Mrs. Morrison, a half-blood Tsimshian from Meqtlak·qā'tla, the interpreter of the Bishop of Caledonia.

PHONETICS.

Vowels:	a, â, e, E, i, o, u.
Consonants:	b, p; w; m; gy, ky; g, k; g·, k·; r, q; h; d, t; n; ds, ts; s; l, tl; y.

A is never pure, but pronounced between *a* and *ä*. Long vowels are by many individuals still further lengthened by repeated intonation; for instance, *iō't* and *iō'ot*, man; *ts'ēn* and *ts'ē'en*, to enter. I have preferred to retain the repeated vowels, except where I was sure that the repetition is only an individual peculiarity. The distinction of surds and sonants is clear, but terminal surds are throughout transformed into sonants whenever a vowel follows. *Ds* and *ts*, however, when followed by an hiatus, are very much alike. *S* is not the English *s*, but has a slight touch of

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[1] The following forms are remarkable:
dEñ gua gyū qē'l? don't you hear? Also: *da gua gyūdE'ñ?*
dEñ gua kunqē'l? don't you smell it? *dā gua skungudE'ñgEñ?*

sh, the point of the tongue not quite touching the teeth. *L* is pronounced, the tip of the tongue touching the upper teeth, the back being pressed against the palate. *N* is similar to *dn*, the nose being almost closed.

All sounds occur as initial sounds. I found the following combinations of consonants beginning words:

pt	kw	qp	nd	tgy	sp	tlp
pts	kt	qk	nts	tk; tkw	sky	tlg
ptl	kts	qt; qtk	nl	tk·	sk	tlk
					sg·	
	ks; ksp, ksk, kstq	qts; qtsky		tq	sk·	
					sq	
		qs; qsk, qst			srl	
					st	
		qtl			stz	

The following consonants occur as terminal sounds:

p, m, ky, k, k·, r, q, t, n, s, l, tl

Terminal combinations of consonants are:

lp	lky	pk	tk·; ntk·	pq	pt	ps	qtl	mqt
		qk	tsk·	mq	k·t; lk·t	ms	ntl	
		tk; ntk, ltk	mk·	tq; ltq	qt	ks; lks, tlks	tstl	
		sk; ksk, nsk, tsk		nq	st; lkst, mst	k·s		
		lk		sq	nt	qs; pqs		
		tlk; mtlk		lq	lt	ns		
					tlt	ls		

GRAMMATICAL NOTES.

PLURAL.

Nouns and verbs form the plural in the same way. Therefore I shall treat this subject before discussing the parts of speech separately.

There is a great variety of plural forms; I observed the following classes:

1. Singular and plural have the same form:

bear, ol.
cat, tō′us (Chinook).
deer, wan.
seal, rE′la.
cedar, g·Elā′r.
arrow, hāuwā′l.
day, ca.
year, k'âtl.
fathom, g·ā′it.
blanket, guc.
to hear, nEqEnō′.
to see, nē.

It seems that all quadrupeds, the dog excepted, belong to this class; also divisions of time and measures.

2. The plural is formed by repetition of the whole word:

dog, has—hashā′s.
foot, sī—sī′sī.
stone, lâp—lEplâ′p.
tree, k·an—k·ank·an.
water, aks—akEa′ks.
flat, tqa—t'aqtqa.
good, ām—amā′m.
to carve, gyetlk—gyetlgyetlk.
to cut, g·'ots—g·'asg·'ots.
to make, ds'ap—ds'apds'ap.
to strike, d'ō′oc—d'Ecdōoc.

It would probably be more proper to join this class to the next:

3. The plural is formed by reduplication.

branch, anē′ic—ananē′ic.
ghost, bā′laq—bilbā′laq.
hat, k·ā′it—k·ak·ā′it.
scar, tlē′eky—tlētlē′eky.
spruce, sE′mEn—sEmsE′mEn.
inside, ds'ār—ds'Eds'ā′r.
sick, sī′epk—sipsī′epk.
to finish, g·ā′ōdē—g·ag·ā′ōdē.
to know, wulā′—wulwulā′.
to look, nē′etsk—neknē′etsk.
to miss, guā′adEc—gutguā′adEc.
to pursue, lōyā′ek—lōlīyā′ek.
to speak, a′lgiaq—ala′lgiaq.
to give, gyEnā′m—gyEngEnā′m.

4. The plural is formed by diæresis:

to hang, yaq—yā'iaq.
to leave the house, ksᴇr—ksâq.

5. The plural is formed by the prefix *lu* (*lī*):

hungry, k'tē—luk'tē.
to be afraid, bāc—lᴇbāc.
to drink, aks—laa'ks.
to laugh, cic'ā'qs—licaā'qs.
to sleep, qstoq—laqstā'iq.
to walk on a road, yāk—liyā'k

6. The plural is formed by the prefix *k·a*:

canoe, qsâ'o—k·aqsâ'o.
face, ts'al—k·ats'ᴇlts'a'l.
tired, cōnā'tl—k·acōnā'tl.
to dress up, nō'otk—k·anō'otk
to leave, dā'wutlt—k·adā'.

7. The plural is formed by the prefix *hū*:

house, wālp—huwā'lp.

8. Singular and plural are derived from the same stem partly by epenthesis; but no rule of formation is evident.

company, nā'tatl—natatltatl (*this may be a distributive*).
man, iō'ot—iō'ota.
raven, k·āq—k·ā'rat.
woman, hanā'aq—hanā'naq.
round, tlkwia'tlk—tlkwɪ'yitlyatlk.
to call, hō'otk—hukhō'otk.
to scream, aya'wa—ayaluwā'da.
to watch, lōma'kca—lōhaya'kca.
to fall down, k·āina—lē'ina.

9. Singular and plural are derived from different stems:

child, tlkuâ'mᴇlk'—k'apᴇtgᴇrᴇ'tlk.
large, wɪ—wu'd'a.
separate, lᴇks—hagul.
to come from, wātk'—amiā'an.
to cry, wīhā'ut (= *large say*)—bâk.
to die, ds'ak'—dᴇr.
to eat, yā'wiqk—tqâ'oqk.
to enter, ts'ē'en—lamts'aq.
to kill, ds'ak'—yets.
to lie (*recline*), nâk—lātlk.
to run, ba—otl.
to sit, d'a—wan.
to stand, hā'yetk—maqsk.
to take, ga—doqtga.

It seems that in compound words only one part of the word takes the plural form:

island, lᴇks d'a = *separate sitting*—lᴇks hūwa'n.
river, g·'alā'aks = *ascending water*—g·'alā'akaks.
stranger, lᴇksgyat = *separate people*—hagulᴇgyat.
town, k·'alts'a'p—k·'alts'apts'a'p.
glad, lō āmak·â'ot = *in good heart*—lō amā'mk·ak·â'ot.

THE NOUN.

There is no grammatical gender, and apparently no oblique case. Possessive relation is either expressed by simply co-ordinating nouns or by the particle ᴇm:

the chief's (1) *house* (2), wālp (2) sᴇm'â'yit (1).
the raven's (1) *master* (2), miā'n (2) k·āq (1).

But *a white man's* (1) *canoe* (2), qsâ'e (2) ᴇm k·'amksī'oa (1).
the door (1) *of the house* (2), lᴇksâ'q (1) ᴇm wā'lbᴇt (2).

As will be seen, the nominative always precedes the genitive. In a few cases I found *n*ᴇ prefixed to the possessed object or to the part:

the man's (1) *canoe* (2), nᴇ qsâ'e (2) iō'ota (1).
the dog's (1) *tail* (2), nᴇ ts'ō'bᴇ (2) has (1).

When the possessor is a person whose name is given, the possessed object takes a terminal *s*:

George's (1) *canoe* (2), qsâ'es Dords (see p. 91).

All other relations are expressed by prepositions, which take a terminal *s* when referring to a *nomen proprium* (see p. 887).

TENSES.

When the object spoken of belongs to the past, that is, if it has perished, or has been destroyed or lost, the noun is used in the past tense, which is formed by the suffix -*d*EE.

the dead man, iō'odEE = *the man that was.*
the broken canoe, qsâ'dEE = *the canoe that was.*

When the object belongs to the future, the noun is used in the future tense, which is formed by the prefix *d*E*m*:

the future husband, dEm naks.
the canoe that will be made, dEm qsâ'E.

This prefix is the same as the characteristic of the future of the verb.

In continuous speech presence and absence are also distinguished, the former being expressed by the suffix *-t*, the latter by *-ga*.

THE ADJECTIVE AND ADVERB.

The adjective precedes the noun, and is generally joined to it by E*m*:

young man, sōp'as Em iō'ot.
married man, naks Em iō'ot.
old man, wud'ā'gyat Em iō'ot (= great person man).
bad man, hada'q Em iō'ot.
good man, ām Em iō'ot.

In some instances *a* stands instead of E*m*:

good man, ām a iō'ot.
But: *bad man*, hada'q a iō'ot, *is obsolete.*

Certain adjectives immediately precede the noun:

large, wī: wī wālp, *a large house.*
wud'a huwālp, *large houses.*
very, important, sEmral.

A number of adjectives are abbreviated in forming compounds:

very, sEmral, *abbreviated*, sEm: sEmhalā'it, *the important dance.*
good for nothing, k·amstE, *abbreviated*, k·am: k·amwālp, *a miserable house.*

The abbreviations cannot be used at pleasure.

K·amstE wālp *and* k·am wālp, *miserable house*, are equally correct; but, while we have atlgE sEmā'm, *not very nice*, sEmā'm would not be correct; it must be sEmral ām, *very nice*.

NOTE.—The meaning differs sometimes, according to whether Em is used or omitted; for instance:

wīhā'u, *to cry*; *from* wī, *great, and* hāu, *to say.*
But: wī Em hāu, *to scold.*

COMPARISON.

I give only a few examples of comparatives:

John is taller than George, k'ā wilē'eks dE John tEst Dsords.
John is smaller than George, k'ā tsō'oske John tEst Dsords.
that is the heaviest, p'a'lEk·s gua'a = that is heavy.

NUMERALS.

The Tsimshian has seven sets of cardinal numbers, which are used for various classes of objects that are counted. The first set is used in counting when there is no definite object referred to; the second class is used for counting flat objects and animals; the third for counting round objects and divisions of time; the fourth for counting men; the fifth for counting long objects, the numerals being composed with *k·an*, tree; the sixth for counting canoes; and the seventh for measures. The last seem to be composed with *ano'n*, hand.

No.	Counting	Flat Objects	Round Objects	Men	Long Objects	Canoes	Measures
1	gyâk'	gâk'	g'E'rEl	k'âl	k·'â'wutsk·an	k·'amâ'et	k·'al
2	t'Epqâ't	t'Epqâ't	gō'upEl	t'Epqadâ'l	g·â'opsk·an	g·'alpē'eltk	gu'lbEl
3	gua'nt	gua'nt	gutlē'	gulâ'l	g·a'ltsk·an	g·altsk·â'ntk	gulē'ont
4	tqâlpq	tqâlpq	tqâlpq	tqâlpqdâ'l	tqâ'apsk·an	tqâlpqsk	tqalpqalo'nt
5	ketonc	ketōnc	ketōnc	kcEnEcâ'l	k·'Etō'Entsk·an	ketō'onsk	ketōnsilo'nt
6	k·'âlt	k·'âlt	k·'âlt	k·'aldâ'l	k·'â'olt-k·an	k·'âltk	k·'âldilo'nt
7	t'Epqâ'lt	t'Epqâ'lt	t'Epqâ'lt	t'Epqaldâ'l	t'Epqâlts·k·an	t'Epqâ'ltk	t'Epqaldilo'nt
8	guandâ'lt	yukta'lt	yuktâ'lt	yuktlēadâ'l	yuk'tlaadsk·an	yuktâ'ltk	yuktaldilo'nt
9	ketEmâ'c	ketEmâ'c	ketEmâ'c	ketEmacâ'l	ketEmâ'etsk·an	ketEmâ'ck	ketEmâsilo'nt
10	gy'ap	gy'ap	k'pē'el	k'pâl	k'pē'etsk·an	gy'apsk	k'pēo'nt
11	gyak'	—	—	k'pâl tE k'âl	—	—	—
12	t'Epqâ't	—	—	k'pâl tE t'Epqadâ'l	—	—	—
20	kyedē'el	—	—	kyedâ'l	—	—	—
30	gulē'wulgyap		—	gulâ'lEgyitk	—	—	—
40	t'Epqadâ'lgyitk tqâlpqwulgya'p		— —	—	—	—	—
50	ketōnewulgyap		—	—	—	—	—
100	kcEnEcâ'l		—	—	—	—	—
200	k'pâl		—	—	—	—	—
300	k'pâl tE kcEnEcâ'l		—	—	—	—	—
400	kyedâ'l		—	—	—	—	—
500	kyEdâ'l tE kcEnEcâl		—	—	—	—	—
600	gulâ'lEgyitk		—	—	—	—	—
700	gulâ'lEgyitk tE kcEnEcâ'l		—	—	—	—	—
800	tqalpqtâ'lEgyitk		—	—	—	—	—
900	tqalpqtâ'lEgyitk tE kcEnEcâ'l			—	—	—	—
1,000	k'pâl		—	—	—	—	—

It will be seen at once that this system is quinary-vigesimal. It seems doubtful whether *tqālpq*, four, is derived from the same root as *t'Epqā't*, two. In five we find the word for 'hand,' *ano'n*, in compounds *on* (?). Six and seven are evidently the second one and two. In twenty we find the word *gyat*, man. The hundreds are identical with the numerals used in counting men, and here the quinary-vigesimal system is most evident.

Ordinal Numbers.

The first has two forms, one for animate, the other for inanimate objects. The following ordinal numbers are formed by means of *naanhiā'*, 'the next to,' and the preceding cardinal numeral, except in the case of the second, when the 'next to the first' is used. The terminal *t* which is here attached to the cardinal numbers is probably nothing else than the terminal euphonic *t* spoken of above.

	Animate	Inanimate
The first:	ksk·â'oq	kstso'q
The second:	naanhiā' ksk·â'oq	naanhiā' kstso'q

The third:

Counting	Flat Objects	Round Objects	Men	Long Objects	Canoes	Measures
naanhiā' t'Ep-qā'dEt	naanhiā' t'Ep-qā'dEt	naanhiā'gō'upElt	naanhiā' t'Ep-qadâ'lt	naanhiā' g·âopsk·anget	naanhiā' galpē'eltk	naanhiā' gu'lbElt

Numeral Adverbs.

once, g'E'rEl.
twice, gō'upEl.
three times, gutlē'
four times, tqâlpq.
five times, ketōnc.

It will be seen that they are identical with the forms used for enumerating round objects.

Distributive.

The distributive numerals are formed by *mEtlE*, followed by the cardinal numeral, for instance, *one (round) to each*: mEtlE g'E'rEl.

PRONOUN.

PERSONAL PRONOUN.

Independent.		Dependent.
I, nE'riō	*me*, gâ'i	*I* (*present*), (n)—ō, *I* (*absent*),—ē
thou, nE'rEn	*thee*, gua(n)	*thou* (mE),—En
he, she (*present*), nē'EdEt	*him, her* (*present*),—	*he, she* (*present*).—Et
——— (*absent*), nē'etga	——— (*absent*).—	——— (*absent*),—Etga, Ega
we, nE'rEm	*us*, g'Em	*we*,—Em
you, nE'rEsEm	(*to*) *you*, guā'sEm	*you*, —EnsEm
they (*present*), dEp nē'EdEt	*them* (*present*), —	*they* (*present*),—Et
——(*absent*), dEp nē'etga	——(*absent*), —	——(*absent*), Etga, Ega

The independent pronoun, the third person excepted, is formed from the stem *nEr*—, the origin of which is unknown to me.

POSSESSIVE PRONOUN.

The independent form of the possessive pronoun is identical with the nominative of the personal pronoun: *mine*, nE'riō, &c.

The dependent possessive pronoun is affixed to the noun to which it belongs. There are distinct forms for the object being present or absent, and three tenses, past, present, and future. There is no difference between the possessive form of the noun and the intransitive verb, and it seems to the writer that according to the logical form of the Tsimshian language both must be considered identical. For this reason it seems possible that the form *nEriō* (I and mine) is formed from the *verbum substantivum nē* and the pronominal suffix. The temporal prefixes and the forms for presence and absence are also identical with those of the verb. The third person plural is omitted, being identical with the singular. Further remarks on these suffixes will be found on p. 884.

—	Past		Present		Future	
	Present	Absent	Present	Absent	Present	Absent
1st person singular . .	nE—ō	nE—ēlaē	—ō	—ēga and —ēla	dEm—ō	dEm—ēlaē
2nd „ „ . .	n—En	n—Enlaē	—EN	—Enga	dEm—En	dEm—Enga
3rd „ present, singular	n—Et	n—Etga	—Et	—Etga	dEm—Et	dEm—Etga
3rd „ absent, „	n—da	n—ga	—daa	—ga	dEm—daa	dEm—ga
1st „ plural . . .	n—Em	n—Emda	—Em	—Emga	dEm—Em	dEm—Emga
2nd „ „ . . .	n—sEm	n—sEmda	—sEm	—sEmga	dEm—sEm	dEm—sEmga

DEMONSTRATIVE PRONOUN.

Presence and absence may best be treated under this heading, as they correspond to a certain extent to our 'this' and 'that.' Absence is designated by the suffixes *-ga* and *-da(a)*, presence by *-t*. I do not know whether there is any difference between the two forms of absence. In continuous speech presence and absence are always expressed by *-ga* and *-t*.

Besides these suffixes, we find the particles (or pronouns) *-asga* = being absent, *-a* = being present, frequently used. The suffix *-ga* is used instead of the imperfect tense, the absence indicating, at the same time, that the action or event belonged to the past. The suffix is always attached to the word the presence or absence of which is to be stated:

nEguā'ts Dsordst, the (present) George's father.
nEguā'ts Dsordsdaa, the (absent) George's father.

The demonstrative pronouns are formed by means of the same suffixes:

this, guē'Et *and* guā'a. *that*, gua'sga.

In sentences our demonstrative pronoun is frequently expressed by the corresponding verbal form:

this man is good, ām iō'odEt. *that man is good*, ām at iō'odEtga.

Demonstrative adverbs are: *here*, guē'E; *there*, ya'gua.

the book here, sāwuus guē'e.

It seems that these suffixes are also attached to words:

your children here, tlguEnē'E.

Some prepositions have separate forms for presence and absence:

at, to, present—da. *at, to, absent*—ga, gasga.

THE VERB.

THE INTRANSITIVE VERB.

Present tense.

		Singular.	Plural.
1st person:		*(n)—ō*	*(dEp)—Em.*
2nd ,,		*(mE)—En*	*(mEsEm)—EnsEm.*
3rd ,,	present:	*—Et (Et)*	*(dEp)—Et(Et).*
3rd ,,	absent:	*—Etga, Ega*	*(dEp)—Etga, Ega.*

The prefixes placed in parentheses are not always used, but seem to serve merely for the purpose of giving greater clearness or emphasis to the sentence.

The imperfect tense is formed by the prefix *nE*—, the future by *dEm*—. It seems that in the imperfect the personal prefixes are almost always used. They are contracted with the temporal character.

—	Imperfect tense		Future tense	
	Singular	Plural	Singular	Plural
1st person . .	nan—ō	nap—Em	dEm (n)—ō	dEm (dEp)—Em
2nd ,, . .	nEm—En	namsEm—EnsEm	dEm (mE)—En	dEm (mEsEm)—EnsEm
3rd ,, present	nE—Et	nap—Et, *or* nE—Et	dEm—Et	dEm (dEp)—Et
3rd ,, absent.	nE—Ega	nap—Ega, *or* nE—Ega	dEm—Ega	dEm (dEp)—Ega

The perfect is formed by *tla* preceding the present tense, the plusquamperfectum and futurum exactum by the characteristic particles of these tenses preceding the perfect.

he has been sick, tla sī'epgEt. *he had been sick*, na tla sī'ēpgEt.

he will have been sick, dEm tla sī'ēpgEt.

INTERROGATIVE.

	Singular.	Plural.
1st person	*—Enawē*	*—Enamē.*
2nd ,,	*mE—Enē'*	*—Esemē.*
3rd ,,	*—ē*	*—ē.*

NEGATIVE.

1st person singular, *atlgE—ē.*		1st person plural, *atlgE—Em*
2nd ,, ,, *atlgE—En.*		2nd ,, ,, *atlgE—EsEm.*
3rd ,, ,, *atlgE—Et.*		3rd ,, ,, *atlgE—Et.*

NOTE.—Nouns and adjectives with the *verbum substantivum* are inflected in the same way as the *verbum intransitivum*. If the noun is accompanied by an adjective, the former is inflected:

I am a Tsimshian, Ts'Emsianō'. *I am a good woman*, ama' hanā'ranō.
you are Tsimshian, Ts'Emsiā'nsEm. *are you a Tsimshian?* Ts'EmsianEnē'?

The third person is frequently expressed by adding the demonstrative pronoun:

they are Tsimshian, Ts'Emsian dEp gua'sga.

Verbum Transitivum.

Object		Singular				Plural	
		1st Person	2nd Person	3rd Person, Present	3rd Person, Absent	1st Person	2nd Person
Singular.	1st person, present	..	mE—ō	t—Enō	t—Enē'ga	..	mEsEm—ō
	1st „ absent	..	mE—ē	t—Enē	t—Enēga	..	mEsEm—ē
	2nd „	n—En	..	t—En	t—Enga	dEp—En	..
	3rd „ present	—ut	—Ent	—EdEt	—EdEt	—Emt	—EsEmt
	3rd „ absent	—ēEga	—Enga	—Etga	—Etga	—Emga	—EsEmga
Plural.	1st „	..	mE—Em	t—EnEm	t—EnEmga	..	mEsEm—Em
	2nd „	n—sEm	..	t—EnsEm	t—EnsEmga	dEp—sEm	..
	3rd „ present	—ut	—Ent	—EdEt	—EdEt	—Emt	—EsEmt
	3rd „ absent	—ēEga	—Enga	—Etga	—Etga	—Emga	—EsEmga

It will be seen that the object generally appears as the suffix of the verb. This makes the inflexion very much like that of the possessive pronoun, and it must probably be understood in the same way as the possessive pronoun; for instance, I see you = I your seeing. In accordance with this fact—that the object appears as the suffix of the verb—is the other: that when the object is in the plural the verb has the plural form, while it has the singular form when the subject is in the plural: *I know you*, nwulwulā'sEm; *you know me*, mEsEm wulā'yō.

The tenses are formed in the same way as those of the intransitive verb.

Interrogative.

Object	Singular		Plural	
	2nd Person	3rd Person	2nd Person	3rd Person
1st person singular	mE—owē	t—owē'	mEsEm—owē	t—owē
2nd „ „	...	t—Enē	...	t—Enē
3rd „ „	—Enē	—Edē	—EsEmē	—Edē
1st „ plural	me—Emē	t—Emē	mEsEm—Emē	t—Emē
2nd „ „	...	t—sEmē	...	t—sEmē
3rd „ „	—Enē	—Edē	—EsEmē	—Edē

In the interrogative there is no distinction of presence and absence.

Negative.

atlgE—.

Object	Singular			Plural	
	1st Person	2nd Person	3rd Person	1st Person	2nd Person
1st person, singular	...	mE—ē	t—ē	...	mEsEm—ē
2nd „ „	n—En	...	t—En	dEp—En	...
3rd „ „	n—t	mE—t	t—t	dEp—t	mEsEm—t
1st „ plural	...	mE—Em	t—Em	...	mEsEm—Em
2nd „ „	n—sEm	...	t—sEm	dEp—sEm	...

Imperative.

I have not reached a satisfactory understanding of the formation of the imperative. The following examples show that the indicative is frequently used for expressing an order:

Singular: eat! yā'wiqgEn! = *thou art eating!* *Plural: eat!* yā'wiqsEm!
drink! a'ksEn! = *thou art drinking!* *drink!* laa'ksEsEm!
sit down! d'ān! = *thou sitst down!* *sit down!* wa'usEm!

In other cases I found the infinitive (stem) of the verb used as in imperative form:

sit down! d'a! *warm the water!* sE gya'muk aks!
come in! ts'ē'en!

Another imperative is formed with the suffix *-tl*:

eat it! gāptl! *look at him!* nē'etl!
take it from me! dē watktl â gâ'i!

The imperative first person plural is formed in various ways:

let us sit down! k'altse wa'nEm!
let us look at him! sō'ntse dEp nē'est!
" " " wa'tse dEp nē'est!
let us go up the river branch! gyilâ' ts'â'tlegua!

The imperative negative is formed with gyilâ'dse! *do not!*

NOTE 1.—It will be noted that in the negative and interrogative the first person singular ends in *ē*, while in the indicative it ends in *ō*. In the former case the person is evidently considered absent.

NOTE 2.—The first person singular has frequently, instead of *-ō*, the suffix *-Enō*. In transitive verbs *-Enō* is used when there is no definite object; for instance, I strike it, *tō'uskEnut*; but: I strike my breast, *tō'usō k'ā'yegō*. In the case of intransitive verbs I am unable to give any rule. The use of *-Enō* or *-ō* depends upon the adverb accompanying the verb. It may be that whenever the state expressed by the verb is defined *-ō* is used.

I am sick, sī'ēpgEnō. *I am always sick*, tlā'wōla sī'ēpgō.
I am tired, sonā'tlEnō. *I am again tired*, tlagyik sonā'tlō.
I am hungry, k'tē'Enō. *I am always hungry*, tlā'wōla k'tē'yō.
I am asleep, qstâ'qEnō. *I want to sleep*, hasā'ran dEm qstâ'qō.

NOTE 3.—When the word terminates with a vowel, *y* is inserted between the end of the stem and *-ō* of the first person singular. The same is done in the case of the first person of the possessive pronoun:

I know, wulā'yō. *I use it*, hâ'yut. *my mother*, nâ'yō.

Frequently a *k* is found inserted. I am not able to explain its use.

PARTICIPLE.

It seems that the present participle is formed by reduplication:

to speak, e'lgyaq. *speaking*, EE'lgyaq.
to sew, tlōopk. *sewing*, tltlō'opk.
to eat, yā'wiqk·. *eating*, hēyā'wiqk·.

The past participle is formed by the suffix *-dē* (see passive).

to sleep, qstâq. *having slept*, qstâqdē.
to walk, ia. *having walked*, iā'dē.
to say, hāu. *having said*, hā'udē.

The verbal substantive is formed by *dEi'n*, and might be more properly classified as a relative sentence:

the maker, na dEi'n ts'a'pdEt = who is he who made it?

I do not know whether there is any difference between this form, referring to a special case, and the general verbal substantive, but it seems to be used also in a general sense:

na dEi'n ts'a'pa qsâ'E, who is the maker of the canoe?

PASSIVE.

It seems that the passive is somewhat irregular. It terminates generally in *-k*, joined to the stem by *s* or *t*.

to tell, matl. *told*, matlk.
to strike, t'ōus. *struck*, t'ō'usk.

to use, hâ.	*used*, hâ'yek.
to see, nē.	*seen*, nē'esk.
to burn, mālq.	*burnt*, mālg·'esk.
to pay, qtkâ.	*paid*, qtkâk.
to pull, sā'ik.	*pulled*, sā'isk.
to send, hā'yets.	*sent*, hā'yetsk.
to hurt, sg·ā'yigs.	*hurt*, sg·ā'yiksk.
to make, ts'ap.	*made*, ts'apsk.
to prepare, guldem k·a'wun.	*prepared*, guldem k·ā'wuntk.
to know, wulā'.	*known*, wulā'itk.
to smoothen, tlE'lEp.	*smoothened*, tlebī'esk.

There are a number of other forms:

to kill, ts'ak.	*killed*, ts'āksa.
to hate, lEbā'lEqs.	*hated*, lEbā'lEqdē.
to do, wāl.	*done*, wā'ldē.
to say, hāu.	*said*, hā'udē.

From these passive forms a present, past, future, &c. are formed in the same wa as from the stem.

DERIVATIVES.

1. Causative, formed by —En and *r'an*:

I cause him to make, ts'a'p'Enūt.
to cause to drink, aksEn
to cause to stop = to hinder, gyilâ'En.
I hinder you to drink, gyilâ'Enō a'ksEn.
I cause him to eat, yāwir'anōt.
it causes him to do, r'anwā'ldet.

2. Inchoative, formed by reduplication:

I get sick, sisī'epgEnō. *I get hungry*, kuk'tē'Enō.
I get tired, sēsonātlEnō.

3. Imitative, formed by *sis-* and by reduplication combined:

I feign to be sick, sissisī'epkEnō. *I feign to be hungry*, siskuk'tē'EgEnō.
I feign to be tired, sissisōnā'tlgEnō. *I feign to sleep*, sisqaqsta'qsEnō.

4. Usitative, expressing something habitual, also anything serious, a necessity, formed by *r'ap*:

I am sick a long while, r'ap sī'epkEnō.
I am in the habit of eating, r'ap yā'wiqgEnō.
I must sleep, r'ap qstâ'qEnō.
I am repeatedly (always) hungry, r'ap tlā'wola k'tē'yō.

Frequentative, formed by *huk*:

he comes repeatedly, huk k·â'EdEksEt.
he is repeatedly sick, huk sī'ēpgEt.

Quotative, formed by *k·a*, which is derived from *amEk·ad*, hearsay:

it is said that he is coming, k·â'EdEksk·a.

Dubitative, formed by sEEn, following the personal suffix:

maybe he is sick, siē'pgEsEEn.
maybe you see me, mEnē'etsēsEEn.

The first person singular has in this derivative always the absent form in *-ē*.

Reflexive.—Although the reflexive is not a real derivative, I may add here that it is formed by lEp gyi'lEks = self back; for instance:

I strike myself, lEp gyi'lEks t'ō'uskEnō.

NOTE.—There are a number of interrogative forms in *tl* which I cannot explain:

is that mine? nEriōtl (na) wā'lde?
is that his? gua'sgatl (na) wā'lde?
will he not come? ā'yentl dEM k·â'EdEksdE?

don't you see him? ā'yentl mEnē'etsdE?
who said it? nātl hā'udE? (*probably = whose saying?*)
where is he who made it? (*he absent*), ndatl na dEi'n ts'a'pdEda?
„ „ (*he present*), nda na dEi'n ts'a'pdEda?
when did he arrive? ndatl da batsgEdEda?
when will he arrive? ndatl dEm da batsgEdEda?
when did you arrive? nda da batsgEn?
when will you arrive? nda dEm da batsgEn?
„ „ tsEdEnda dEm da batsgEn?
whose house is it? nātl wālbE guā'a?

I add a few sentences that will be found of interest from a syntactic point of view:

I shall cause you not to come, ātlgEn dEm k·â'EdEksEnt.
maybe he is not coming, ā'yensEntl dEm k·â'EdEkst.
do you hear that he is not coming? nEqnō'yentl dEm wa k·â'EdEksdE?
I hear he is sick, nEqEnō'yō siē'pgEtgE.
he says he (another man) is sick, ma'tldEdE sī'ēpgEdEt.
I hope it will be good weather, nEsEntl āmtl laqa'.
I hope he is not sick, nEsEntl wa sī'epgEdE.
I wish to drink, sā'rau dEm a'ksō.
I order him to come, gunâ'yō dEm k·â'EdEksEt = I order his future coming.
I see you are eating, nē'etsō wul yā'niqk·En = I see where you eat.
it is mine, nē'et nE'riō.
it is George, nēnē'es Dsords.
I might fall down, k·ā'inanē gyē'En.
you might fall down, k·ā'inaEn gyē'En.
if I fall, I shall hurt myself, tsEda sak·ā'inaē, dEm sg·ā'iksgEnō.
if I had fallen, I should have hurt myself, amē'en tsE sak·ā'inaē nān dEm sg·ā'iksgEnō.
I give the knife to you, gyeha'mō hatlEbī'etsgEda guan.

NOTE.—Every word referring to a person, more especially to a nomen proprium, takes the suffix *-s*:

George's canoe, qsâ'Es Dsords.
George and John, Dsords dis Dsōn (*in other cases*: ditl).

FORMATION OF WORDS.

It may be well to call attention to a few of the formative elements and to the manner of composing words. One of the most remarkable features of the Tsimshian vocabulary is the indiscriminate use of words for nouns and verbs but still more that of words as prepositions and verbs. Among these we note:

wātk, from and to come.
ga, at and to take.
ksâq, out and to leave the house.
da, with, at and to elope, to take with.
ts'E'lEm, into and to put into.

We may say in a general way that the prepositions serve at the same time as verbs expressing a motion or location corresponding to the preposition.

Among formative elements of words we note the following:

am, used for: *amhalā'it*, headdress = used in dance.
wī, large: *wīhāldE*, many; *wud'Egyat*, old = great people.
wīhāut, to cry.
wō, without: *wōnlō'otlk*, without nest (a name).
wōksenā'tlk, without breath (a name).
wōk·'ā'uts, without labret = girl.

k-, place of, only occurring in geographical names:

Laq(1)-*k*(2)-*tlqua*(3)-*ralā'ms*(4) = on (1) where (2) little (3) haws (4); an island near Fort Simpson.
KEnE(1)-*k*(2)-*qâ'lē*(3) = place (1) where (2) scalps (3).

Mᴇqtla(1)-*k*(2)-*qā'tla*(3) = narrow channel (1) where (2) sea (3).
Laq(1)-*k*(2)-*lān*(3) = on (1) where (2) (Gyit)lan (3); village of the Gyitlan.

Kᴇnᴇ-, place of:

Kᴇnᴇ(1)-*k*(2)-*qâ'lē*(3) = place (1) where (2) scalps (3).
Kᴇnᴇ(1)-*k·anā'ō*(2) = place of (1) trade (2).

(*kun*-, place of, Gyitksan dialect.)

kspᴇ-, place where something is frequently done:

Kspᴇ(1)-*k·amē'elᴇq*(2) = where always (1) good for nothing say (2) = playground.
Kspᴇ(1)-*d'ā*(2) = where one always (1) sits (2).
Kspᴇ(1)-*sōnt*(2) = where always (1) in summer (2).

k·am-, miserable, good for nothing, from *k·amtse*:

k·amē'eleq = good for nothing to speak = to play.

k·an-, instrument:

k·anwā'i, rowlock = rowing instrument.
k·antlō'opes, thimble = sewing instrument.

q-, to eat, to receive:

qpēianō, to smoke = to eat smoke.
qgyat, man-eater.
qana'ē, bread-eater.
qlōan'o'n, to receive payment for burial (*lō*, into; *an'o'n*, hand).

q—ka, misfortune happening:

qhasī'epka, having sickness.
wulaqtlâotk, when a landslide went down.

qpī-, half, in part, from *qpīyē'*:

qpīmâ'k, partially white.

ha-, instrument (cf. *hâ*, to use):

haaks, cup, spoon = drinking instrument.
haa'lagyaq, windpipe = speaking instrument.
hayā'wiqk·, fork = eating instrument.
had'ō'osk, broom = sweeping instrument.

ha-, causative:

hasī'epk, causing sickness.
halemā'tk, causing salvation, saviour (Olachen).

ts'ᴇm-, in:

ts'ᴇm aks, = in water, a sea monster.
ts'ᴇm ts'aq = in nose, nostril.
ts'ᴇm ᴇn'o'n = in hand, palm of hand.

tsē-, future:

tsēdᴇ'nda, when? (future)
tsēgyētsē'ip, to-morrow.

sᴇ-, to make:

sᴇ wulā'isk = to make relative, to adopt.
sᴇ wulā' = to make know, to teach.

wul-, where something is done (only once, not habitually):

wul (1) *gyileks* (2) *tqal* (3) *d'amtk* (4) = where (1) self (2) on (3) written (4); a place on Nass River.

ndᴇ-, place where something is kept:

ndᴇsu'ga, sugar-bowl.

I add translations of a few names:

Geographical names:

Laq (1) *-k* (2) *-spaqtl* (3), Aberdeen = on (1) where (2) catch salmon (3).
Gyat (1) *laq* (2) *q* (3) *tsâ'oks* (4) = People on eat canoe-boards = people of village where they steal canoe-boards (*ktsâ'oks*).
Gyat (1) *Ksia'n* (2) = people (1) of the Ksian (2) (Skeena).
Ksian, probably from *aks mian* = the main river.
Ts'Emsiā'n = on the Ksian.

Names of persons:

Na (1) *gun* (2) *aks* (3), what (1) mistaken for (2) water (3).
Tsaq·a (1) *dī* (2) *lā'o* (3), across the water (1) also (2) staying (3).
TsEREn (1) *sā'gyisk* (2), ashore (1) pulling (2).
Ts'Enslâ'ek, the one left alone.
Ts'Eba'sa, either overcast sky = close eye sky, or fastened talon (of eagle).
Wīha', great wind.
Nebât, making noise to each other.
Ndsē'ets le'itlks, grandmother of watching.
Nēs wība'sk, grandfather great storm.
Hats'Eqsnē'eq, dreadful fire.
DEm dī mâksk, going to be white.
Nēs yulâ'ops, grandfather carrying stones.
Lī d'am laq t'ā'ō, sitting on ice.
Seo'pgyibā'yuk, flying in front of town early in morning.
Saraitk·ak·'ā'i, eagle having one coloured wing.
Qpī'yelEk, contracted from *qpī'litl haq'ulō'oq* = partly hairy sea-monster.
Hok·qsān ram Neqnoq = unbeliever in Neqnoq.

I cannot satisfactorily explain the formation of the last five names.

IV. Kutona'qa.

PHONETICS.

Vowels: a, e, E, i, o, u; au.

Consonants:—p; m, w; d, t; n; g, k; g·, k·; — q, h; s, ts; — tl; y.

Initial and terminal combinations of consonants are very scarce. Among my collection of words only a few initial, and no terminal combinations are found. The former are: *kt*, *sk*, *sk·*, *st*, *tsg·*, *tsp*, *tlk*, *tln*. As all words are undoubtedly compounds, numerous combinations occur in words, one consonant being the terminal sound of one part of the word, the other the initial sound of the subsequent part.

GRAMMATICAL NOTES.

THE NOUN.

Singular and plural have no separate forms. There are no cases. The genitive is frequently expressed by the possessive pronoun. *K'atlaqā'atsin aqktlā'mis*, the horse's head.

In such cases in which we use the indefinite article the suffix *-nām*, designating somebody's or some, is attached to the noun.

aqk·'unā'nām, a tooth, somebody's tooth.
aqgitlā'nām, a house.
aqk'atluma'nām, a mouth.

A great number of nouns have the prefix *aq-* or begin with compounds of this prefix and certain others. I am unable to explain the meaning of this prefix, which does not form an integral part of the word, being dropped in certain syntactic forms.

aqgitla, the house (stem: *tla*).
inika gitla, it is my house.
sān tlanā'menē, there is a house.

aqkinmi'tuk, river:

sān mitu'kenē, there is a river.

THE ADJECTIVE

The adjective precedes the noun.

PRONOUN.

Personal Pronoun.

I, *kāmin.*	we, *kamina'tla.*
thou, *ni'nkō.*	you, *ninkō'nisgītl.*
he, *ninkō'is.*	they, *ninkō'isis.*

Possessive Pronoun.

my, *ka—.*	our, *ka—na'tla.*
thy, *—nis.*	your, *—ni'sgītl.*
his, *—is.*	their, *—isis.*

The independent form of the possessive pronoun is identical with the personal pronoun:

kā'min, it is mine.

NUMERALS.

Cardinals.

1, *ō'kwē.*	9, *g·aiki't'ōwō.*
2, *ās.*	10, *ē't'ōwō.*
3, *g·a'tlsa.*	20, *ai'wō.*
4, *qā'tsa.*	30, *g·atlsa'nōwō.*
5, *īē'hkō.*	100, *gyit'uwō'nōwō.*
6, *nmi'sa.*	200, *ās tlEt'uwō'nōwō.*
7, *nsta'tlā.*	300, *g·atlsa tlEt'uwō'nōwō.*
8, *ōuqā'tsa.*	1,000, *gyi't'owō tlEt'uwō'nōwō.*

In some cases I found the prefix *ga-* added to the numerals one and two:

g'ō'kwē aqktsemā'kinik, one man.
g'ō'kwē ni'tlgō, one dollar.
g'ō'kwē a'qtlat, one fathom.
g'ō'kwē natā'nik, one month.
gia'sē natā'nik, two months.

The following is remarkable:

ā'snē qā'atltsin, two dogs.

Ordinals.

the first, *o'smēt.* the second, *as* the third, *g·a'tlsa;* &c.

Numeral Adverbs.

once, *ōkk·ena'.* twice, *a'sk·'atl.* three times, *g·a'tlsak·'atl.*
the first time, ō'pāk. *the second time*, ask·'astl; &c.

Partitives.

one-half, ās tlsEkosE'ka. *one-third*, g·a'tlsa tlsEkosE'ka.

THE VERB.

The Intransitive Verb.

Indicative.

—	Present tense	Imperfect tense	Future tense
1st pers. sing.	ku—nē	mā-ku—nē	ku-tsqatl—nē'nē
2nd „ „	gin—nē	mā-gin—nē	gin-tsqatl—nē'nē
3rd „ „	i—nē	mā(k)—nē	(i)-tsqatl—nē'nē
1st „ plur.	ku—natla(anē)	mā-ku—natla(anē)	ku-tsqatl—natla(anē)
2nd „ „	gin—nī'gitl	mā-gin—nī'gitl	gin-tsqatl—nī'gitl(nē)
3rd „ „	—nenā'menē	mā(k)—nenā'menē	(ī)-tsqatl—nenā'menē

The intransitive verb may also be inflected by means of an auxiliary verb *i*, as follows:

	Present tense	Imperfect tense	Future tense
1st pers. sing.	kuinē—nē	mā-kuinē—nē	ku-tsqatl-inē'nē—nē.
	&c.	&c.	&c.

The attributive verb is formed in the same way, or by means of the auxiliary verb *i*:

For instance: *kusā'nē*, or *kuinē sānē*, I am bad.

The noun does not take the verbal suffixes and prefixes, but is used with the auxiliary verb:

gin inē Kutona'qa, you are a Kootonay.
k·'a'pē inē Kutona'qa, they are all Kootonay.
inē kagitla, it is my house.

Imperative.

2nd person singular: —ēn; for instance: *ī'kēn*, eat! *g·'ō'mēn(ē)*, sleep!
2nd ,, plural: —ētl; ,, *ī'kētl*, eat!

Interrogative.

The interrogative particle is *k·an* or *naqk·an*, which, however, is not used when it is self-evident that a question is meant:

naqk·an gin-g·'ō'menē? and *gin g·'ō'menē*? are you asleep?
naqk·an gin inē Kutona'qa? and *gin inē Kutona'qa*? are you a Kootonay?
k·an inē ka'min? is it mine?
k·an inē aqgitlā'is? is that his house?

After an interrogative pronoun the particle is omitted:

g·atla kī'ē? who is that?

Negative.

The negative is formed by the prefix *k·'a*, which follows the pronominal prefix:

ku-k·'a-santlqō'onē, I am not sick (= bad body).

Iterative.

The iterative is formed by *tla*, which follows the pronominal prefix:

ku-tla-santlqō'onē, I am again sick.

Optative.

The optative is formed by a compound particle, composed of the particles designating future and past. It is, therefore, a futurum exactum.

tsqᴇ-ma kui'kenē, I should like to drink.

The future is also used to express a desiderative.

ku-tsqatl-i'kenē, I shall drink, and I want to drink.

Quotative and Responsive.

If the verb is said in answer to a question, or in repetition of a sentence heard from another speaker, the prefix *slu* is used.

slu-watlenketlatlō'nā, somebody said it is snowing.
ku-slu-wa'qē, I am coming (said in reply to a question).
slu-i'kenē, they say that he eats.

TRANSITIVE VERB.

Indicative, Present Tense.

Object	Singular			Plural	
	1st Person	2nd Person	3rd Person	1st Person	2nd Person
1st person singular	—	gin—nā'penē	—nā'penē	—	gin—napgi'tlnē
2nd " "	ku—nisenē	—	—ni'senē	wō—nauwā'senē	—
3rd " "	kun—nkō'is	gin—	—	wō—	gin—agi'tlnē
1st " plural	—	gin—nauwā'senē	—nauwā'senē	—	gin—nauwā'senē
2nd " "	ku—nisgi'tlnē	—	—nisgi'tlnē	wō—nisgī'tlnē	—
3rd " "	ku—ni'nkōis	gin—natlā'anē	—	wō—natlā'anē	gin—natlā'anē

The third persons plural and singular are identical.

For instance, from *nu-k·ō*, to conquer:

kunuk·ōni'senē, I conquer thee.
kunnuk·ōnkō'is, I conquer him.
nuk·ōnā'penē, he conquers me.
nuk·ōni'senē, he conquers thee.
ōnuk·ōnauwā'senē, we conquer thee; &c.

PASSIVE.

ku k·antla'tltitl, I am struck.
George nu-k·o-a'tlnē, George has been beaten.
ku-k·ō-atl, I am beaten.

FORMATION OF WORDS.

I have not succeeded in analysing many words, but a number of prefixes and suffixes have resulted from my comparisons. Among the words of the vocabulary I collected, 164 begin with the prefix *aq* above referred to. Besides this I found a number of other prefixes.

gia-, animal:

gia'kqō, fish.
giak·'anu'koat, eagle.
gia'k·'ᴇtla, duck.
gianu'kqō, mountain-goat.
gianuqtlū'mena, rabbit.
giantli'kqō, ground hog.
giaū'ats, fool hen.

nu-, another prefix of animal names:

nuk·tsa'k·tlē, humming-bird.
nuk·tlu'k·oēn, loon.
nutlaketli'tlik·, hawk.
nutlqamiū'at, snail.
nutlō'k·at, the white tail deer.
nutltō'kup, antelope.

Here may also belong:

gia-nu'k·qō, mountain-goat.
gia-nuqtlū'mena, rabbit.
giantlikqō, ground hog.

gu-, separable prefix. Meaning unknown.

gu-wi'tlk·a, large.
gu-atla'sk·in, to break off.
gu-wanak·anā'nām, war.
gu-watlāk·uk·u'k·ut, rain.

-k'a-, opening of:

aqk'asatlā'gak, opening of nose = nostril.
aqk'atle'ma, opening of œsophagus = mouth.
aqk'atlaqāu'ᴇit, opening of house = door.

-k·ak-, central part, dividing line:

aqk·ā'nek·ak, notch of arrow.
aqkink·aksa'tla, septum.

-gak suffix occurring in names of many parts of body:

aqk'a-satlā'gak, nostril.
aqguwi'tᴇgāk, breast.
aqgē'igak, foot.
aqkō'igak, wrist.
aqg·oatg·'atliga'k, eyebrow.
aqg·'a'tligak, forehead.
aqgu'ngak, beak.
akqa'sgak, breastbone.
aqgō'ugak, neck.
aqgōguptlā'mgāk, nape.

-wōk, tree:

katlā'wōk, thorn.
skōmō'wōk, sarvis (?) berry bush.
aqkunā'wōk, willow.
aqkitlmā'kwōk, cherry tree.
aqkuwā'tlwōk, birch.

-tlqō, body:

sān, bad.
sōke, good.
k'a, broad.
sā'ntlqō, sick.
sō'kētlqō, well.
k'a'tlqō, stout.

-mōtl, instrument:

yīwakī'umōtl, brush.
itli'nmōtl, instrument.
ksakō'mōtl, net = dipping instrument.
gāmtlōkenōk'ō'mōtl, sling.
g'ak·tsqō'mōtl, pestle.
itluktsō'mōtl, sewing machine.
anankō'mōtl, broom.

-kin, to do something with hand or foot:

yī'wakin, to paint.
aqtsᴇ'kin, to crush with foot.
yā'tsikin, to stand on top of something.
g·asni'nkin, to break.
guatla'skin, to break off.
hā'wutskin, to hold in hand.
itkin, to make something with the hand.
atlkin, to carry in hand.

-gan, to do something with teeth:

gug·a'sqan, to bite off a piece.
g·asni'nqan, to break by biting.

-qō, to do something by hammering:

(g')a'ktsqō, to pound.
guatla'sqō, to break off with hammer.
g·asitlu'qō, to break to pieces with hammer.
g·aktsē'tlmakqō, to pound.

-mik, vibrate:

atlaskū'mik, a cut.
aqkayi'nmik, a war.

[A comparative vocabulary of all the languages of British Columbia, including the principal dialects, will be given in a future report.]

DESCRIPTION OF PLATES.

Plate X., Fig. 1. Tsimshian, male, *circ.* 55 years [*col.* Boas, No. 85]. *Norma frontalis.*
,, Fig. 2. Tsimshian, *circ.* 50 years. [Morton collection in the Museum of the Academy of Natural Sciences, Philadelphia, No. 213.] *Norma frontalis.*
Plate XI., Fig. 1. Tsimshian. [Morton collection in the Museum of the Academy of Natural Sciences, Philadelphia, No. 214.] *Norma frontalis.*
,, Fig. 2. Tsimshian, *circ.* 18 years. [Morton collection in the Museum of the Academy of Natural Sciences, Philadelphia, No. 987.] *Norma frontalis.*
Plate XII., Fig. 1. Same as Plate X., Fig. 1. *Norma lateralis.*
,, Fig. 2. Same as Plate X., Fig. 2. *Norma lateralis.*
Plate XIII., Fig. 1. Same as Plate XI., Fig. 1. *Norma lateralis.*
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Plate XIV., Fig. 1. Same as Plate X., Fig. 1. *Norma verticalis.*
,, Fig. 2. Same as Plate X., Fig. 2. *Norma verticalis.*
Plate XV., Fig. 1. Same as Plate XI., Fig. 1. *Norma verticalis.*
,, Fig. 2. Same as Plate XI., Fig. 2. *Norma verticalis*

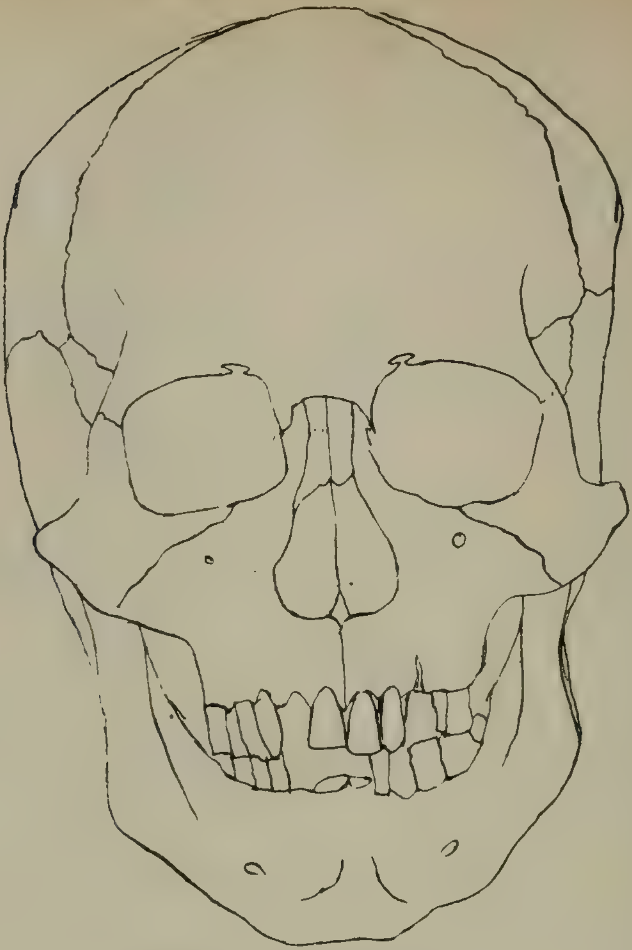
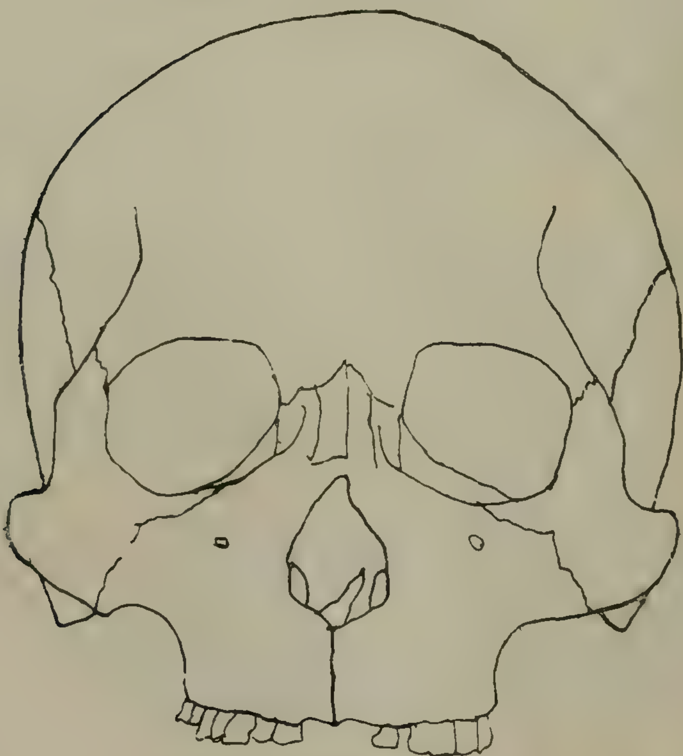


FIG. 1.—Half natural size. ♂



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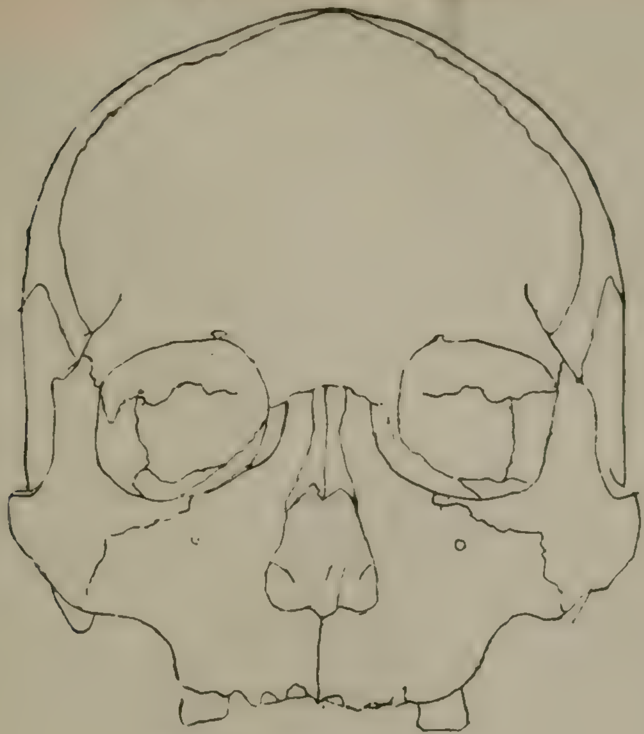

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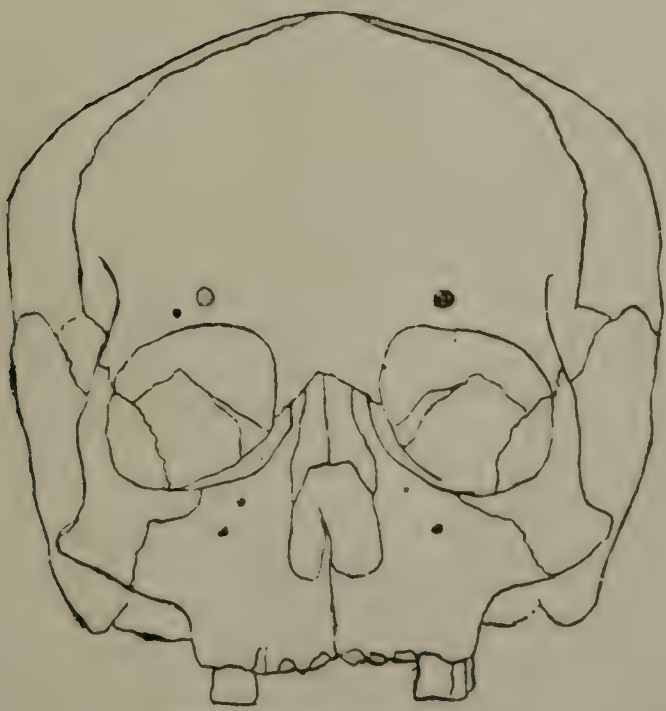

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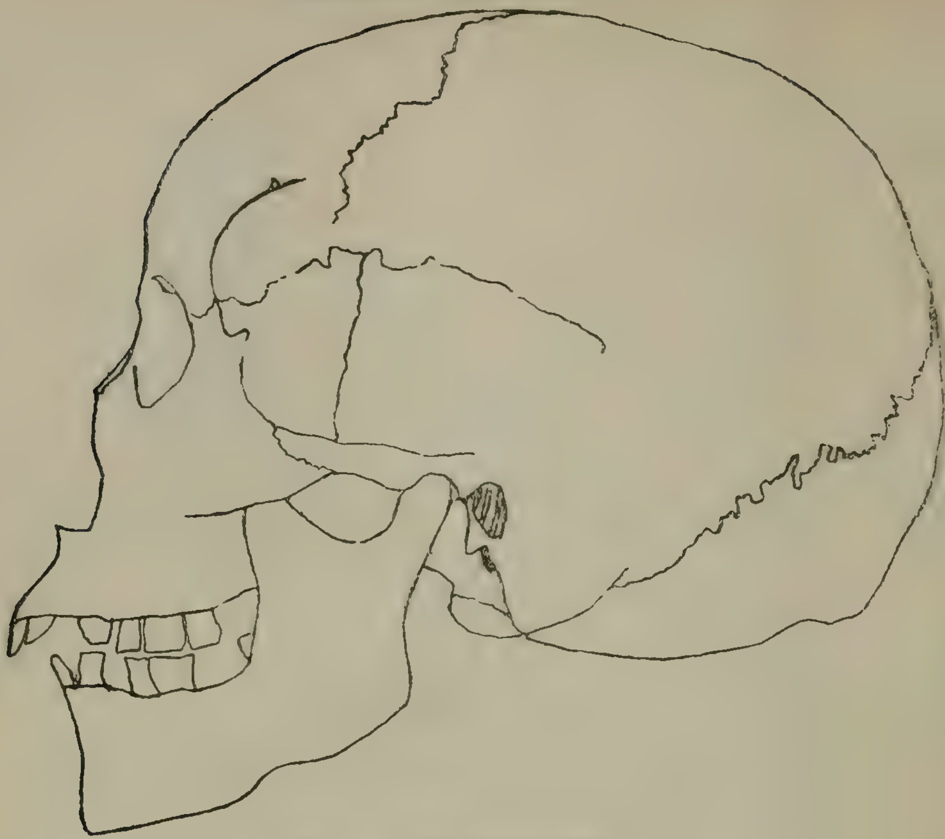

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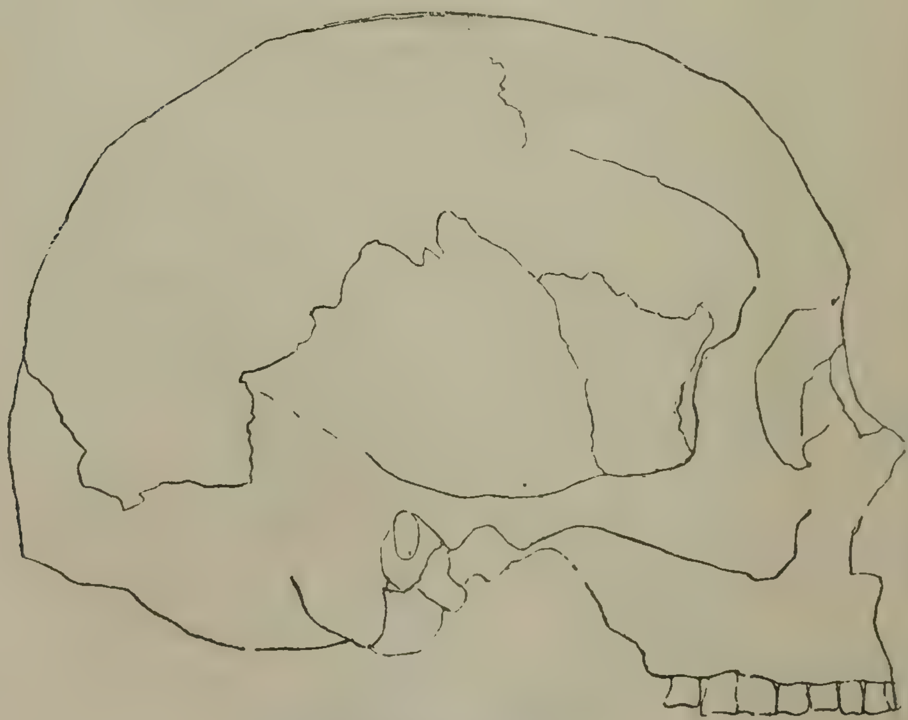

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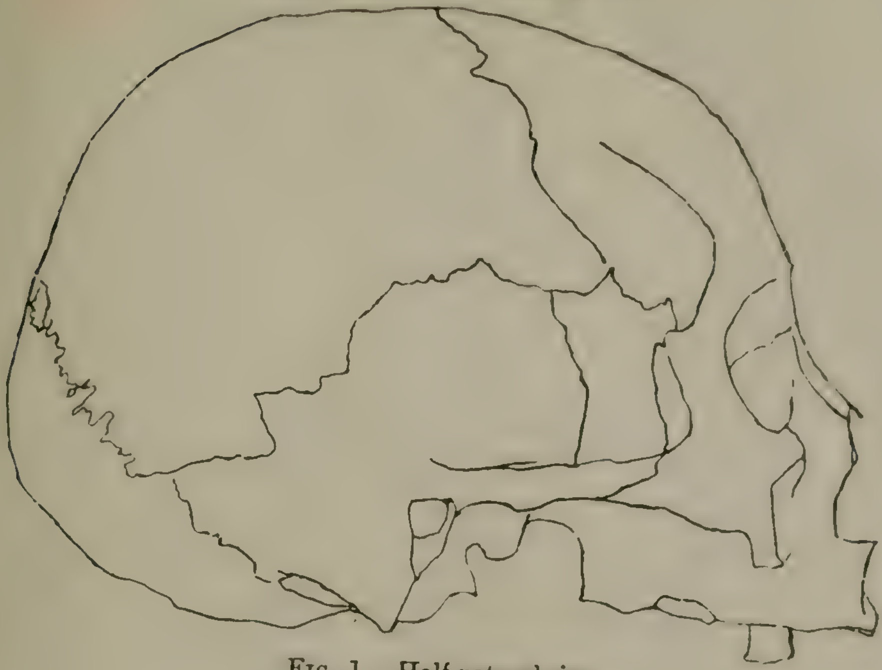

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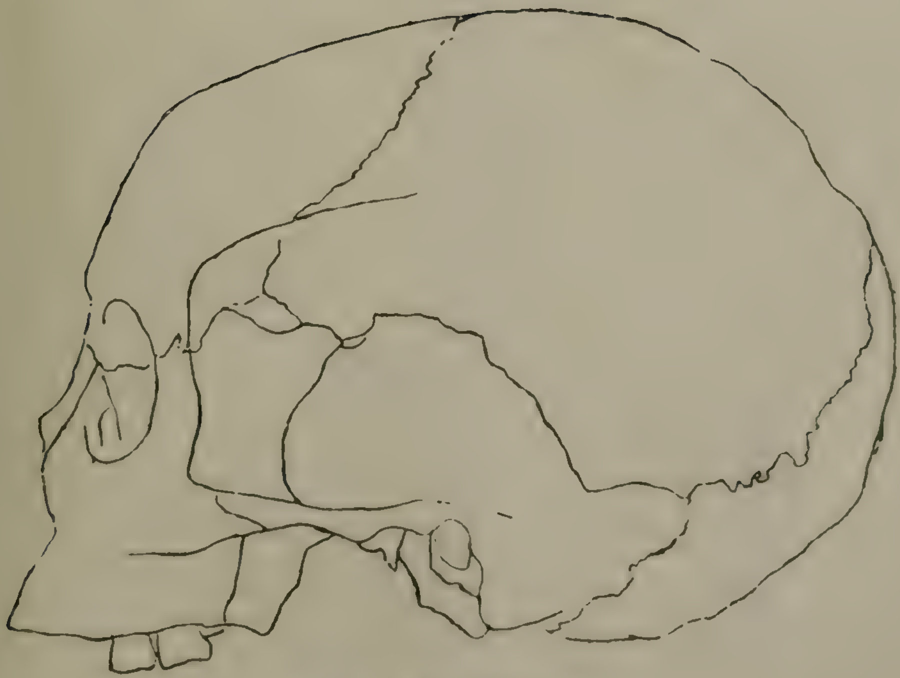

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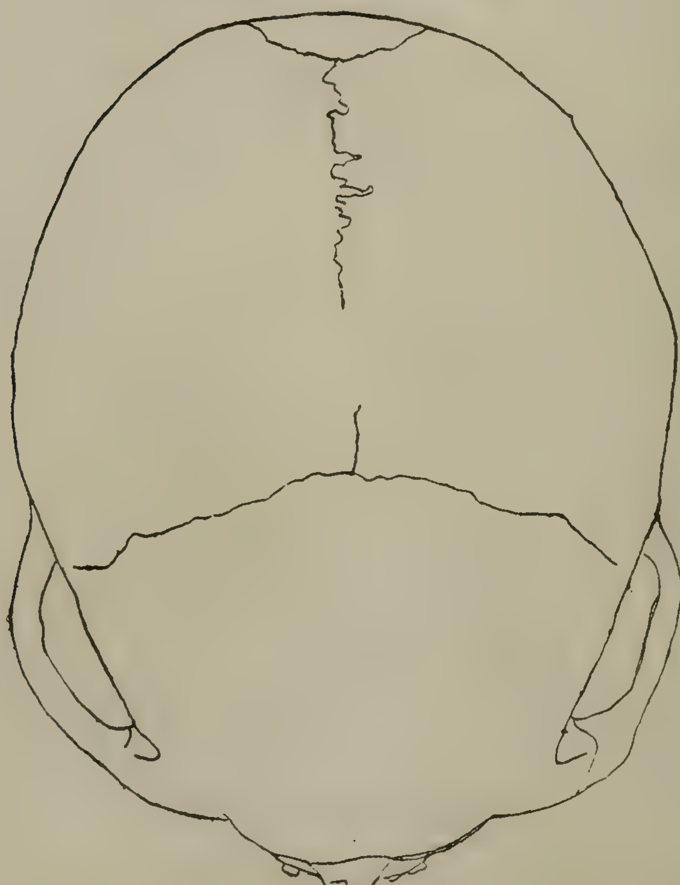

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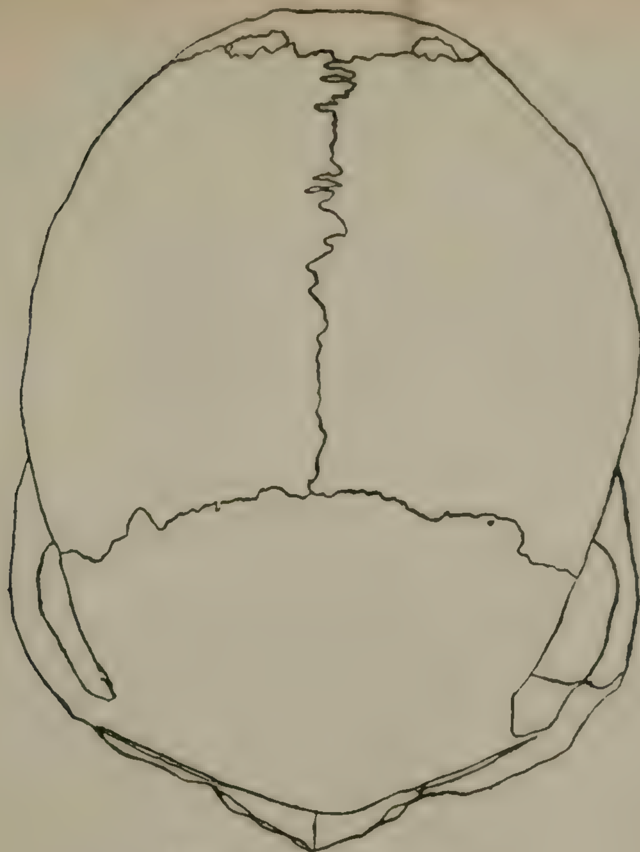

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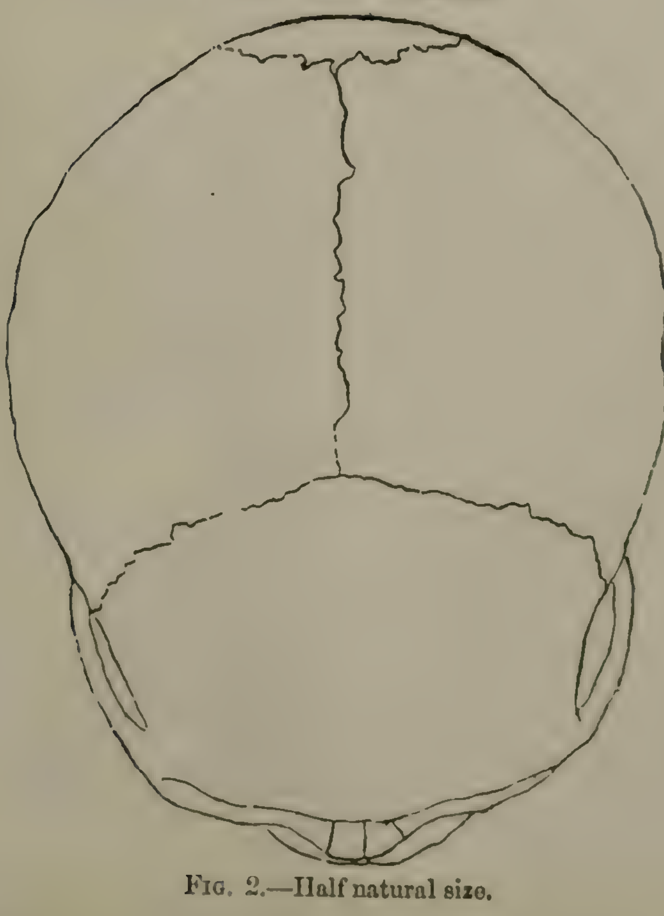

Fig. 2.—Half natural size.

INDEX.

[*An asterisk* (*) *signifies that no abstract of the communication is given.*]

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CONTENTS:—Proceedings of the Meeting;—John Taylor, on Mineral Veins;—Dr. Lindley, on the Philosophy of Botany;—Dr. Henry, on the Physiology of the Nervous System;—P. Barlow, on the Strength of Materials;—S. H. Christie, on the Magnetism of the Earth;—Rev. J. Challis, on the Analytical Theory of Hydrostatics and Hydrodynamics;—G. Rennie, on Hydraulics as a Branch of Engineering, Part I.;—Rev. G. Peacock, on certain Branches of Analysis.

Together with Papers on Mathematics and Physics, Philosophical Instruments and Mechanical Arts, Natural History, Anatomy, Physiology, and History of Science.

PROCEEDINGS OF THE FOURTH MEETING, at Edinburgh, 1834, *Published at* 15*s.*

CONTENTS:—H. G. Rogers, on the Geology of North America;—Dr. C. Henry, on the Laws of Contagion;—Prof. Clark, on Animal Physiology;—Rev. L. Jenyns, on Zoology;—Rev. J. Challis, on Capillary Attraction;—Prof. Lloyd, on Physical Optics;—G. Rennie, on Hydraulics, Part II.

Together with the Transactions of the Sections, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE FIFTH MEETING, at Dublin, 1835, *Published at* 13*s.* 6*d.* (Out of Print.)

CONTENTS :—Rev. W. Whewell, on the Recent Progress and Present Condition of the Mathematical Theories of Electricity, Magnetism, and Heat ;—A. Quetelet, Aperçu de l'Etat actuel des Sciences Mathématiques chez les Belges ;—Capt. E. Sabine, on the Phenomena of Terrestrial Magnetism.

Together with the Transactions of the Sections, Prof. Sir W. Hamilton's Address and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE SIXTH MEETING, at Bristol, 1836, *Published at* 12*s.* (Out of Print.)

CONTENTS :—Prof. Daubeny, on the Present State of our Knowledge with respect to Mineral and Thermal Waters ;—Major E. Sabine, on the Direction and Intensity of the Terrestrial Magnetic Force in Scotland ;—J. Richardson, on North American Zoology ;—Rev. J. Challis, on the Mathematical Theory of Fluids ;—J. T. Mackay, a Comparative View of the more remarkable Plants which characterize the neighbourhood of Dublin and Edinburgh, and the South-west of Scotland, &c. ;—J. T. Mackay, Comparative Geographical Notices of the more remarkable Plants which characterize Scotland and Ireland ;—Report of the London Sub-Committee of the Medical Section on the Motions and Sounds of the Heart ;—Second Report of the Dublin Sub-Committee on the Motions and Sounds of the Heart ;—Report of the Dublin Committee on the Pathology of the Brain and Nervous System ;—J. W. Lubbock, Account of the Recent Discussions of Observations of the Tides ;—Rev. B. Powell, on determining the Refractive Indices for the Standard Rays of the Solar Spectrum in various media ;—Dr. Hodgkin, on the Communication between the Arteries and Absorbents ;—Prof. Phillips, Report of Experiments on Subterranean Temperature ; —Prof. Hamilton, on the Validity of a Method recently proposed by G. B. Jerrard, for Transforming and Resolving Equations of Elevated Degrees.

Together with the Transactions of the Sections, Prof. Daubeny's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE SEVENTH MEETING, at Liverpool, 1837, *Published at* 16*s.* 6*d.* (Out of Print.)

CONTENTS :—Major E. Sabine, on the Variations of the Magnetic Intensity observed at different points of the Earth's Surface ;—Rev. W. Taylor, on the various modes of Printing for the Use of the Blind ;—J. W. Lubbock, on the Discussions of Observations of the Tides ;—Prof. T. Thompson, on the Difference between the Composition of Cast Iron produced by the Cold and Hot Blast ;—Rev. T. R. Robinson, on the Determination of the Constant of Nutation by the Greenwich Observations ;—R. W. Fox, Experiments on the Electricity of Metallic Veins, and the Temperature of Mines ;—Provisional Report of the Committee of the Medical Section of the British Association, appointed to investigate the Composition of Secretions, and the Organs producing them ;—Dr. G. O. Rees, Report from the Committee for inquiring into the Analysis of the Glands, &c., of the Human Body ;—Second Report of the London Sub-Committee of the British Association Medical Section, on the Motions and Sounds of the Heart ;—Prof. Johnston, on the Present State of our Knowledge in regard to Dimorphous Bodies ;—Lieut.-Col. Sykes, on the Statistics of the four Collectorates of Dukhun, under the British Government ;—E. Hodgkinson, on the relative Strength and other Mechanical Properties of Iron obtained from the Hot and Cold Blast ;—W. Fairbairn, on the Strength and other Properties of Iron obtained from the Hot and Cold Blast ;—Sir J. Robinson and J. S. Russell, Report of the Committee on Waves ;—Note by Major Sabine, being an Appendix to his Report on the Variations of the Magnetic Intensity observed at different Points of the Earth's Surface ; —J. Yates, on the Growth of Plants under Glass, and without any free communication with the outward Air, on the Plan of Mr. N. J. Ward, of London.

Together with the Transactions of the Sections, Prof. Traill's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE EIGHTH MEETING, at Newcastle, 1838, *Published at* 15*s*. (Out of Print.)

CONTENTS:—Rev. W. Whewell, Account of a Level Line, measured from the Bristol Channel to the English Channel, by Mr. Bunt;—Report on the Discussions of Tides, prepared under the direction of the Rev. W. Whewell;—W. S. Harris, Account of the Progress and State of the Meteorological Observations at Plymouth;—Major E. Sabine, on the Magnetic Isoclinal and Isodynamic Lines in the British Islands;—Dr. Lardner, on the Determination of the Mean Numerical Values of Railway Constants;—R. Mallet, First Report upon Experiments upon the Action of Sea and River Water upon Cast and Wrought Iron;—R. Mallet, on the Action of a Heat of 212° Fahr., when long continued, on Inorganic and Organic Substances.

Together with the Transactions of the Sections, Mr. Murchison's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE NINTH MEETING, at Birmingham, 1839, *Published at* 13*s*. 6*d*. (Out of Print.)

CONTENTS:—Rev. B. Powell, Report on the Present State of our Knowledge of Refractive Indices, for the Standard Rays of the Solar Spectrum in different media; Report on the Application of the Sum assigned for Tide Calculations to Rev. W. Whewell, in a letter from T. G. Bunt, Esq.;—H. L. Pattinson, on some Galvanic Experiments to determine the Existence or Non-Existence of Electrical Currents among Stratified Rocks, particularly those of the Mountain Limestone formation, constituting the Lead Measures of Alton Moor;—Sir D. Brewster, Reports respecting the Two Series of Hourly Meteorological Observations kept in Scotland;—Report on the subject of a series of Resolutions adopted by the British Association at their Meeting in August 1838, at Newcastle;—R. Owen, Report on British Fossil Reptiles;—E. Forbes, Report on the Distribution of the Pulmoniferous Mollusca in the British Isles;—W. S. Harris, Third Report on the Progress of the Hourly Meteorological Register at Plymouth Dockyard.

Together with the Transactions of the Sections, Rev. W. Vernon Harcourt's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE TENTH MEETING, at Glasgow, 1840, *Published at* 15*s*. (Out of Print.)

CONTENTS:—Rev. B. Powell, Report on the Recent Progress of discovery relative to Radiant Heat, supplementary to a former Report on the same subject inserted in the first volume of the Reports of the British Association for the Advancement of Science;—J. D. Forbes, Supplementary Report on Meteorology;—W. S. Harris, Report on Prof. Whewell's Anemometer, now in operation at Plymouth;—Report on 'The Motion and Sounds of the Heart,' by the London Committee of the British Association, for 1839-40;—Prof. Schönbein, an Account of Researches in Electro-Chemistry;—R. Mallet, Second Report upon the Action of Air and Water, whether fresh or salt, clear or foul, and at various temperatures, upon Cast Iron, Wrought Iron, and Steel;—R. W. Fox, Report on some Observations on Subterranean Temperature;—A. F. Osler, Report on the Observations recorded during the years 1837, 1838, 1839, and 1840, by the Self-registering Anemometer erected at the Philosophical Institution, Birmingham;—Sir D. Brewster, Report respecting the Two Series of Hourly Meteorological Observations kept at Inverness and Kingussie, from Nov. 1st, 1838, to Nov. 1st, 1839;—W. Thompson, Report on the Fauna of Ireland: Div. *Vertebrata*;—C. J. B. Williams, M.D., Report of Experiments on the Physiology of the Lungs and Air-Tubes;—Rev. J. S. Henslow, Report of the Committee on the Preservation of Animal and Vegetable Substances.

Together with the Transactions of the Sections, Mr. Murchison and Major E. Sabine's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE ELEVENTH MEETING, at Plymouth, 1841, *Published at* 13*s*. 6*d*.

CONTENTS:—Rev. P. Kelland, on the Present State of our Theoretical and Experimental Knowledge of the Laws of Conduction of Heat;—G. L. Roupell, M.D.,

Report on Poisons;—T. G. Bunt, Report on Discussions of Bristol Tides, under the direction of the Rev. W. Whewell;—D. Ross, Report on the Discussions of Leith Tide Observations, under the direction of the Rev. W. Whewell;—W. S. Harris, upon the working of Whewell's Anemometer at Plymouth during the past year;—Report of a Committee appointed for the purpose of superintending the scientific co-operation of the British Association in the System of Simultaneous Observations in Terrestrial Magnetism and Meteorology;—Reports of Committees appointed to provide Meteorological Instruments for the use of M. Agassiz and Mr. M'Cord;—Report of a Committee appointed to superintend the Reduction of Meteorological Observations;—Report of a Committee for revising the Nomenclature of the Stars;—Report of a Committee for obtaining Instruments and Registers to record Shocks and Earthquakes in Scotland and Ireland;—Report of a Committee on the Preservation of Vegetative Powers in Seeds;—Dr. Hodgkin, on Inquiries into the Races of Man;—Report of the Committee appointed to report how far the Desiderata in our knowledge of the Condition of the Upper Strata of the Atmosphere may be supplied by means of Ascents in Balloons or otherwise, to ascertain the probable expense of such Experiments, and to draw up Directions for Observers in such circumstances;—R. Owen, Report on British Fossil Reptiles;—Reports on the Determination of the Mean Value of Railway Constants;—Dr. D. Lardner, Second and concluding Report on the Determination of the Mean Value of Railway Constants;—E. Woods, Report on Railway Constants;—Report of a Committee on the Construction of a Constant Indicator for Steam Engines.

Together with the Transactions of the Sections, Prof. Whewell's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE TWELFTH MEETING, at Manchester, 1842, *Published at* 10*s*. 6*d*.

CONTENTS:—Report of the Committee appointed to conduct the co-operation of the British Association in the System of Simultaneous Magnetical and Meteorological Observations;—Dr. J. Richardson, Report on the present State of the Ichthyology of New Zealand;—W. S. Harris, Report on the Progress of Meteorological Observations at Plymouth;—Second Report of a Committee appointed to make Experiments on the Growth and Vitality of Seeds;—C. Vignoles, Report of the Committee on Railway Sections;—Report of the Committee for the Preservation of Animal and Vegetable Substances;—Dr. Lyon Playfair, Abstract of Prof. Liebig's Report on Organic Chemistry applied to Physiology and Pathology;—R. Owen, Report on the British Fossil Mammalia, Part I.;—R. Hunt, Researches on the Influence of Light on the Germination of Seeds and the Growth of Plants;—L. Agassiz, Report on the Fossil Fishes of the Devonian System or Old Red Sandstone;—W. Fairbairn, Appendix to a Report on the Strength and other Properties of Cast Iron obtained from the Hot and Cold Blast;—D. Milne, Report of the Committee for Registering Shocks of Earthquakes in Great Britain;—Report of a Committee on the construction of a Constant Indicator for Steam-Engines, and for the determination of the Velocity of the Piston of the Self-acting Engine at different periods of the Stroke;—J. S. Russell, Report of a Committee on the Form of Ships;—Report of a Committee appointed 'to consider of the Rules by which the Nomenclature of Zoology may be established on a uniform and permanent basis;'—Report of a Committee on the Vital Statistics of Large Towns in Scotland;—Provisional Reports, and Notices of Progress in Special Researches entrusted to Committees and Individuals.

Together with the Transactions of the Sections, Lord Francis Egerton's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE THIRTEENTH MEETING, at Cork, 1843, *Published at* 12*s*.

CONTENTS:—Robert Mallet, Third Report upon the Action of Air and Water, whether fresh or salt, clear or foul, and at Various Temperatures, upon Cast Iron, Wrought Iron, and Steel;—Report of the Committee appointed to conduct the Cooperation of the British Association in the System of Simultaneous Magnetical and Meteorological Observations;—Sir J. F. W. Herschel, Bart., Report of the Committee appointed for the Reduction of Meteorological Observations;—Report of the Committee appointed for Experiments on Steam-Engines;—Report of the Committee ap-

pointed to continue their Experiments on the Vitality of Seeds;—J. S. Russell, Report of a Series of Observations on the Tides of the Frith of Forth and the East Coast of Scotland;—J. S. Russell, Notice of a Report of the Committee on the Form of Ships;—J. Blake, Report on the Physiological Action of Medicines;—Report of the Committee on Zoological Nomenclature;—Report of the Committee for Registering the Shocks of Earthquakes, and making such Meteorological Observations as may appear to them desirable;—Report of the Committee for conducting Experiments with Captive Balloons;—Prof. Wheatstone, Appendix to the Report;—Report of the Committee for the Translation and Publication of Foreign Scientific Memoirs;—C. W. Peach, on the Habits of the Marine Testacea;—E. Forbes, Report on the Mollusca and Radiata of the Ægean Sea, and on their distribution, considered as bearing on Geology;—L. Agassiz, Synoptical Table of British Fossil Fishes, arranged in the order of the Geological Formations;—R. Owen, Report on the British Fossil Mammalia, Part II.;—E. W. Binney, Report on the excavation made at the junction of the Lower New Red Sandstone with the Coal Measures at Collyhurst;—W. Thompson, Report on the Fauna of Ireland: Div. *Invertebrata;*—Provisional Reports, and Notices of Progress in Special Researches entrusted to Committees and Individuals.

Together with the Transactions of the Sections, the Earl of Rosse's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE FOURTEENTH MEETING, at York, 1844, *Published at* £1.

CONTENTS:—W. B. Carpenter, on the Microscopic Structure of Shells;—J. Alder and A. Hancock, Report on the British Nudibranchiate Mollusca;—R. Hunt, Researches on the Influence of Light on the Germination of Seeds and the Growth of Plants;—Report of a Committee appointed by the British Association in 1840, for revising the Nomenclature of the Stars;—Lieut.-Col. Sabine, on the Meteorology of Toronto in Canada;—J. Blackwall, Report on some recent researches into the Structure, Functions, and Economy of the *Araneidea* made in Great Britain;—Earl of Rosse, on the Construction of large Reflecting Telescopes;—Rev. W. V. Harcourt, Report on a Gas-furnace for Experiments on Vitrifaction and other Applications of High Heat in the Laboratory;—Report of the Committee for Registering Earthquake Shocks in Scotland;—Report of a Committee for Experiments on Steam-Engines;—Report of the Committee to investigate the Varieties of the Human Race;—Fourth Report of a Committee appointed to continue their Experiments on the Vitality of Seeds;—W. Fairbairn, on the Consumption of Fuel and the Prevention of Smoke;—F. Ronalds, Report concerning the Observatory of the British Association at Kew;—Sixth Report of the Committee appointed to conduct the Co-operation of the British Association in the System of Simultaneous Magnetical and Meteorological Observations;—Prof. Forchhammer on the influence of Fucoidal Plants upon the Formations of the Earth, on Metamorphism in general, and particularly the Metamorphosis of the Scandinavian Alum Slate;—H. E. Strickland, Report on the Recent Progress and Present State of Ornithology;—T. Oldham, Report of Committee appointed to conduct Observations on Subterranean Temperature in Ireland;—Prof. Owen, Report on the Extinct Mammals of Australia, and descriptions of certain Fossils indicative of the former existence in that continent of large Marsupial Representatives of the Order Pachydermata;—W. S. Harris, Report on the working of Whewell and Osler's Anemometers at Plymouth, for the years 1841, 1842, 1843;—W. R. Birt, Report on Atmospheric Waves;—L. Agassiz, Rapport sur les Poissons Fossiles de l'Argile de Londres, with translation;—J. S. Russell, Report on Waves;—Provisional Reports, and Notices of Progress in Special Researches entrusted to Committees and Individuals.

Together with the Transactions of the Sections, the Dean of Ely's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE FIFTEENTH MEETING, at Cambridge, 1845, *Published at* 12*s*.

CONTENTS:—Seventh Report of a Committee appointed to conduct the Co-operation of the British Association in the System of Simultaneous Magnetical and Meteorological Observations;—Lieut.-Col. Sabine, on some Points in the Meteorology

of Bombay;—J. Blake, Report on the Physiological Actions of Medicines;—Dr. Von Boguslawski, on the Comet of 1843;—R. Hunt, Report on the Actinograph;—Prof. Schönbein, on Ozone;—Prof. Erman, on the Influence of Friction upon Thermo-Electricity;—Baron Senftenberg, on the Self-registering Meteorological Instruments employed in the Observatory at Senftenberg;—W. R. Birt, Second Report on Atmospheric Waves;—G. R. Porter, on the Progress and Present Extent of Savings Banks in the United Kingdom;—Prof. Bunsen and Dr. Playfair, Report on the Gases evolved from Iron Furnaces, with reference to the Theory of Smelting of Iron;—Dr. Richardson, Report on the Ichthyology of the Seas of China and Japan;—Report of the Committee on the Registration of Periodical Phenomena of Animals and Vegetables;—Fifth Report of the Committee on the Vitality of Seeds;—Appendix, &c.

Together with the Transactions of the Sections, Sir J. F. W. Herschel's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE SIXTEENTH MEETING, at Southampton, 1846, *Published at* 15*s*.

CONTENTS:—G. G. Stokes, Report on Recent Researches in Hydrodynamics;—Sixth Report of the Committee on the Vitality of Seeds;—Dr. Schunck, on the Colouring Matters of Madder;—J. Blake, on the Physiological Action of Medicines;—R. Hunt, Report on the Actinograph;—R. Hunt, Notices on the Influence of Light on the Growth of Plants;—R. L. Ellis, on the Recent Progress of Analysis;—Prof. Forchhammer, on Comparative Analytical Researches on Sea Water;—A. Erman, on the Calculation of the Gaussian Constants for 1829;—G. R. Porter, on the Progress, present Amount, and probable future Condition of the Iron Manufacture in Great Britain;—W. R. Birt, Third Report on Atmospheric Waves;—Prof. Owen, Report on the Archetype and Homologies of the Vertebrate Skeleton;—J. Phillips, on Anemometry;—Dr. J. Percy, Report on the Crystalline Flags;—Addenda to Mr. Birt's Report on Atmospheric Waves.

Together with the Transactions of the Sections, Sir R. I. Murchison's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE SEVENTEENTH MEETING, at Oxford, 1847, *Published at* 18*s*.

CONTENTS:—Prof. Langberg, on the Specific Gravity of Sulphuric Acid at different degrees of dilution, and on the relation which exists between the Development of Heat and the coincident contraction of Volume in Sulphuric Acid when mixed with Water;—R. Hunt, Researches on the Influence of the Solar Rays on the Growth of Plants;—R. Mallet, on the Facts of Earthquake Phenomena;—Prof. Nilsson, on the Primitive Inhabitants of Scandinavia;—W. Hopkins, Report on the Geological Theories of Elevation and Earthquakes;—Dr. W. B. Carpenter, Report on the Microscopic Structure of Shells;—Rev. W. Whewell and Sir James C. Ross, Report upon the Recommendation of an Expedition for the purpose of completing our Knowledge of the Tides;—Dr. Schunck, on Colouring Matters;—Seventh Report of the Committee on the Vitality of Seeds;—J. Glynn, on the Turbine or Horizontal Water-Wheel of France and Germany;—Dr. R. G. Latham, on the present state and recent progress of Ethnographical Philology;—Dr. J. C. Prichard, on the various methods of Research which contribute to the Advancement of Ethnology, and of the relations of that Science to other branches of Knowledge;—Dr. C. C. J. Bunsen, on the results of the recent Egyptian researches in reference to Asiatic and African Ethnology, and the Classification of Languages;—Dr. C. Meyer, on the Importance of the Study of the Celtic Language as exhibited by the Modern Celtic Dialects still extant;—Dr. Max Müller, on the Relation of the Bengali to the Aryan and Aboriginal Languages of India;—W. R. Birt, Fourth Report on Atmospheric Waves;—Prof. W. H. Dove, Temperature Tables, with Introductory Remarks by Lieut.-Col. E. Sabine;—A. Erman and H. Petersen, Third Report on the Calculation of the Gaussian Constants for 1829.

Together with the Transactions of the Sections, Sir Robert Harry Inglis's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE EIGHTEENTH MEETING, at Swansea, 1848, *Published at* 9*s.*

CONTENTS:—Rev. Prof. Powell, A Catalogue of Observations of Luminous Meteors;—J. Glynn, on Water-pressure Engines;—R. A. Smith, on the Air and Water of Towns;—Eighth Report of Committee on the Growth and Vitality of Seeds;—W. R. Birt, Fifth Report on Atmospheric Waves;—E. Schunck, on Colouring Matters;—J. P. Budd, on the advantageous use made of the gaseous escape from the Blast Furnaces at the Ystalyfera Iron Works;—R. Hunt, Report of progress in the investigation of the Action of Carbonic Acid on the Growth of Plants allied to those of the Coal Formations;—Prof. H. W. Dove, Supplement to the Temperature Tables printed in the Report of the British Association for 1847;—Remarks by Prof. Dove on his recently constructed Maps of the Monthly Isothermal Lines of the Globe, and on some of the principal Conclusions in regard to Climatology deducible from them; with an introductory Notice by Lieut.-Col. E. Sabine;—Dr. Daubeny, on the progress of the investigation on the Influence of Carbonic Acid on the Growth of Ferns;—J. Phillips, Notice of further progress in Anemometrical Researches;—Mr. Mallet's Letter to the Assistant-General Secretary;—A. Erman, Second Report on the Gaussian Constants;—Report of a Committee relative to the expediency of recommending the continuance of the Toronto Magnetical and Meteorological Observatory until December 1850.

Together with the Transactions of the Sections, the Marquis of Northampton's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE NINETEENTH MEETING, at Birmingham, 1849, *Published at* 10*s.*

CONTENTS:—Rev. Prof. Powell, A Catalogue of Observations of Luminous Meteors;—Earl of Rosse, Notice of Nebulæ lately observed in the Six-feet Reflector;—Prof. Daubeny, on the Influence of Carbonic Acid Gas on the health of Plants, especially of those allied to the Fossil Remains found in the Coal Formation;—Dr. Andrews, Report on the Heat of Combination;—Report of the Committee on the Registration of the Periodic Phenomena of Plants and Animals;—Ninth Report of Committee on Experiments on the Growth and Vitality of Seeds;—F. Ronalds, Report concerning the Observatory of the British Association at Kew, from Aug. 9, 1848 to Sept. 12, 1849;—R. Mallet, Report on the Experimental Inquiry on Railway Bar Corrosion;—W. R. Birt, Report on the Discussion of the Electrical Observations at Kew.

Together with the Transactions of the Sections, the Rev. T. R. Robinson's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE TWENTIETH MEETING, at Edinburgh, 1850, *Published at* 15*s.* (Out of Print.)

CONTENTS:—R. Mallet, First Report on the Facts of Earthquake Phenomena;—Rev. Prof. Powell, on Observations of Luminous Meteors;—Dr. T. Williams, on the Structure and History of the British Annelida;—T. C. Hunt, Results of Meteorological Observations taken at St. Michael's from the 1st of January, 1840, to the 31st of December, 1849;—R. Hunt, on the present State of our Knowledge of the Chemical Action of the Solar Radiations;—Tenth Report of Committee on Experiments on the Growth and Vitality of Seeds;—Major-Gen. Briggs, Report on the Aboriginal Tribes of India;—F. Ronalds, Report concerning the Observatory of the British Association at Kew;—E. Forbes, Report on the Investigation of British Marine Zoology by means of the Dredge;—R. MacAndrew, Notes on the Distribution and Range in depth of Mollusca and other Marine Animals, observed on the coasts of Spain, Portugal, Barbary, Malta, and Southern Italy in 1849;—Prof. Allman, on the Present State of our Knowledge of the Freshwater Polyzoa;—Registration of the Periodical Phenomena of Plants and Animals;—Suggestions to Astronomers for the Observation of the Total Eclipse of the Sun on July 28, 1851.

Together with the Transactions of the Sections, Sir David Brewster's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE TWENTY-FIRST MEETING, at Ipswich, 1851, *Published at* 16*s.* 6*d.*

CONTENTS:—Rev. Prof. Powell, on Observations of Luminous Meteors;—Eleventh Report of Committee on Experiments on the Growth and Vitality of Seeds;—Dr. J. Drew, on the Climate of Southampton;—Dr. R. A. Smith, on the Air and Water of Towns: Action of Porous Strata, Water, and Organic Matter;—Report of the Committee appointed to consider the probable Effects in an Economical and Physical Point of View of the Destruction of Tropical Forests;—A. Henfrey, on the Reproduction and supposed Existence of Sexual Organs in the Higher Cryptogamous Plants;—Dr. Daubeny, on the Nomenclature of Organic Compounds;—Rev. Dr. Donaldson, on two unsolved Problems in Indo-German Philology;—Dr. T. Williams, Report on the British Annelida;—R. Mallet, Second Report on the Facts of Earthquake Phenomena;—Letter from Prof. Henry to Col. Sabine, on the System of Meteorological Observations proposed to be established in the United States;—Col. Sabine, Report on the Kew Magnetographs;—J. Welsh, Report on the Performance of his three Magnetographs during the Experimental Trial at the Kew Observatory;—F. Ronalds, Report concerning the Observatory of the British Association at Kew, from September 12, 1850, to July 31, 1851;—Ordnance Survey of Scotland.

Together with the Transactions of the Sections, Prof. Airy's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE TWENTY-SECOND MEETING, at Belfast, 1852, *Published at* 15*s.*

CONTENTS:—R. Mallet, Third Report on the Facts of Earthquake Phenomena;—Twelfth Report of Committee on Experiments on the Growth and Vitality of Seeds;—Rev. Prof. Powell, Report on Observations of Luminous Meteors, 1851–52;—Dr. Gladstone, on the Influence of the Solar Radiations on the Vital Powers of Plants;—A Manual of Ethnological Inquiry;—Col. Sykes, Mean Temperature of the Day, and Monthly Fall of Rain at 127 Stations under the Bengal Presidency;—Prof. J. D. Forbes, on Experiments on the Laws of the Conduction of Heat;—R. Hunt, on the Chemical Action of the Solar Radiations;—Dr. Hodges, on the Composition and Economy of the Flax Plant;—W. Thompson, on the Freshwater Fishes of Ulster;—W. Thompson, Supplementary Report on the Fauna of Ireland;—W. Wills, on the Meteorology of Birmingham;—J. Thomson, on the Vortex-Water-Wheel;—J. B. Lawes and Dr. Gilbert, on the Composition of Foods in relation to Respiration and the Feeding of Animals.

Together with the Transactions of the Sections, Colonel Sabine's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE TWENTY-THIRD MEETING, at Hull, 1853, *Published at* 10*s.* 6*d.*

CONTENTS:—Rev. Prof. Powell, Report on Observations of Luminous Meteors, 1852–53;—James Oldham, on the Physical Features of the Humber;—James Oldham, on the Rise, Progress, and Present Position of Steam Navigation in Hull;—William Fairbairn, Experimental Researches to determine the Strength of Locomotive Boilers, and the causes which lead to Explosion;—J. J. Sylvester, Provisional Report on the Theory of Determinants;—Professor Hodges, M.D., Report on the Gases evolved in Steeping Flax, and on the Composition and Economy of the Flax Plant;—Thirteenth Report of Committee on Experiments on the Growth and Vitality of Seeds;—Robert Hunt, on the Chemical Action of the Solar Radiations;—Dr. John P. Bell, Observations on the Character and Measurements of Degradation of the Yorkshire Coast;—First Report of Committee on the Physical Character of the Moon's Surface, as compared with that of the Earth;—R. Mallet, Provisional Report on Earthquake Wave-Transits; and on Seismometrical Instruments;—William Fairbairn, on the Mechanical Properties of Metals as derived from repeated Meltings, exhibiting the maximum point of strength and the causes of deterioration;—Robert Mallet, Third Report on the Facts of Earthquake Phenomena (continued).

Together with the Transactions of the Sections, Mr. Hopkins's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE TWENTY-FOURTH MEETING, at Liverpool, 1854, *Published at* 18*s*.

CONTENTS:—R. Mallet, Third Report on the Facts of Earthquake Phenomena (continued);—Major-General Chesney, on the Construction and General Use of Efficient Life-Boats;—Rev. Prof. Powell, Third Report on the present State of our Knowledge of Radiant Heat;—Colonel Sabine, on some of the results obtained at the British Colonial Magnetic Observatories;—Colonel Portlock, Report of the Committee on Earthquakes, with their proceedings respecting Seismometers;—Dr. Gladstone, on the Influence of the Solar Radiations on the Vital Powers of Plants, Part 2;—Rev. Prof. Powell, Report on Observations of Luminous Meteors, 1853–54; —Second Report of the Committee on the Physical Character of the Moon's Surface; —W. G. Armstrong, on the Application of Water-Pressure Machinery;—J. B. Lawes and Dr. Gilbert, on the Equivalency of Starch and Sugar in Food;—Archibald Smith, on the Deviations of the Compass in Wooden and Iron Ships;—Fourteenth Report of Committee on Experiments on the Growth and Vitality of Seeds.

Together with the Transactions of the Sections, the Earl of Harrowby's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE TWENTY-FIFTH MEETING, at Glasgow, 1855, *Published at* 15*s*.

CONTENTS:—T. Dobson, Report on the Relation between Explosions in Coal-Mines and Revolving Storms;—Dr. Gladstone, on the Influence of the Solar Radiations on the Vital Powers of Plants growing under different Atmospheric Conditions, Part 3;—C. Spence Bate, on the British Edriophthalma;—J. F. Bateman, on the present state of our knowledge on the Supply of Water to Towns;—Fifteenth Report of Committee on Experiments on the Growth and Vitality of Seeds;—Rev. Prof. Powell, Report on Observations of Luminous Meteors, 1854–55;—Report of Committee appointed to inquire into the best means of ascertaining those properties of Metals and effects of various modes of treating them which are of importance to the durability and efficiency of Artillery;—Rev. Prof. Henslow, Report on Typical Objects in Natural History;—A. Follett Osler, Account of the Self-registering Anemometer and Rain-Gauge at the Liverpool Observatory;—Provisional Reports.

Together with the Transactions of the Sections, the Duke of Argyll's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE TWENTY-SIXTH MEETING, at Cheltenham, 1856, *Published at* 18*s*.

CONTENTS:—Report from the Committee appointed to investigate and report upon the effects produced upon the Channels of the Mersey by the alterations which within the last fifty years have been made in its Banks;—J. Thomson, Interim Report on progress in Researches on the Measurement of Water by Weir Boards;—Dredging Report, Frith of Clyde, 1856;—Rev. B. Powell, Report on Observations of Luminous Meteors, 1855–1856;—Prof. Bunsen and Dr. H. E. Roscoe, Photochemical Researches;—Rev. James Booth, on the Trigonometry of the Parabola, and the Geometrical Origin of Logarithms;—R. MacAndrew, Report on the Marine Testaceous Mollusca of the North-east Atlantic and neighbouring Seas, and the physical conditions affecting their development;—P. P. Carpenter, Report on the present state of our knowledge with regard to the Mollusca of the West Coast of North America;—T. C. Eyton, Abstract of First Report on the Oyster Beds and Oysters of the British Shores;—Prof. Phillips, Report on Cleavage, and Foliation in Rocks, and on the Theoretical Explanations of these Phenomena, Part 1;—Dr. T. Wright, on the Stratigraphical Distribution of the Oolitic Echinodermata;—W. Fairbairn, on the Tensile Strength of Wrought Iron at various Temperatures;—C. Atherton, on Mercantile Steam Transport Economy;—J. S. Bowerbank, on the Vital Powers of the Spongiadæ;—Report of a Committee upon the Experiments conducted at Stormontfield, near Perth, for the artificial propagation of Salmon;—Provisional Report on the Measurement of Ships for Tonnage;—On Typical Forms of Minerals, Plants and Animals for Museums;—J. Thomson, Interim Report on Progress in Researches on the Measurement of Water by Weir Boards;—R. Mallet, on

Observations with the Seismometer;—A. Cayley, on the Progress of Theoretical Dynamics;—Report of a Committee appointed to consider the formation of a Catalogue of Philosophical Memoirs.

Together with the Transactions of the Sections, Dr. Daubeny's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE TWENTY-SEVENTH MEETING, at Dublin, 1857, *Published at* 15*s*.

CONTENTS:—A. Cayley, Report on the recent progress of Theoretical Dynamics;—Sixteenth and Final Report of Committee on Experiments on the Growth and Vitality of Seeds;—James Oldham, C.E., continuation of Report on Steam Navigation at Hull;—Report of a Committee on the Defects of the present methods of Measuring and Registering the Tonnage of Shipping, as also of Marine Engine-Power, and to frame more perfect rules, in order that a correct and uniform principle may be adopted to estimate the Actual Carrying Capabilities and Working-power of Steam Ships;—Robert Were Fox, Report on the Temperature of some Deep Mines in Cornwall;—Dr. G. Plarr, de quelques Transformations de la Somme $\Sigma_{t_0}^{-a} \frac{a^{t|+1}\beta^{t|+1}\delta^{t|+1}}{1^{t|+1}\gamma^{t|+1}\epsilon^{t|+1}}$ a étant entier négatif, et de quelques cas dans lesquels cette somme est exprimable par une combinaison de factorielles, la notation $a^{t|+1}$ désignant le produit des facteurs $\alpha\ (\alpha+1)\ (\alpha+2)$ &c.... $(\alpha+t-1)$;—G. Dickie, M.D., Report on the Marine Zoology of Strangford Lough, County Down, and corresponding part of the Irish Channel;—Charles Atherton, Suggestions for Statistical Inquiry into the Extent to which Mercantile Steam Transport Economy is affected by the Constructive Type of Shipping, as respects the Proportions of Length, Breadth, and Depth;—J. S. Bowerbank, Further Report on the Vitality of the Spongiadæ;—Dr. John P. Hodges, on Flax;—Major-General Sabine, Report of the Committee on the Magnetic Survey of Great Britain;—Rev. Baden Powell, Report on Observations of Luminous Meteors, 1856–57;—C. Vignoles, on the Adaptation of Suspension Bridges to sustain the passage of Railway Trains;—Prof. W. A. Miller, on Electro-Chemistry;—John Simpson, Results of Thermometrical Observations made at the *Plover's* Wintering-place, Point Barrow, latitude 71° 21′ N., long. 156° 17′ W., in 1852–54;—Charles James Hargreave, on the Algebraic Couple; and on the Equivalents of Indeterminate Expressions;—Thomas Grubb, Report on the Improvement of Telescope and Equatorial Mountings;—Prof. James Buckman, Report on the Experimental Plots in the Botanical Garden of the Royal Agricultural College at Cirencester;—William Fairbairn, on the Resistance of Tubes to Collapse;—George C. Hyndman, Report of the Proceedings of the Belfast Dredging Committee;—Peter W. Barlow, on the Mechanical Effect of combining Girders and Suspension Chains, and a Comparison of the Weight of Metal in Ordinary and Suspension Girders, to produce equal deflections with a given load;—J. Park Harrison, Evidences of Lunar Influence on Temperature;—Report on the Animal and Vegetable Products imported into Liverpool from the years 1851 to 1855 (inclusive);—Andrew Henderson, Report on the Statistics of Life-boats and Fishing-boats on the Coasts of the United Kingdom.

Together with the Transactions of the Sections, the Rev. H. Lloyd's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE TWENTY-EIGHTH MEETING, at Leeds, September 1858, *Published at* 20*s*.

CONTENTS:—R. Mallet, Fourth Report upon the Facts and Theory of Earthquake Phenomena;—Rev. Prof. Powell, Report on Observations of Luminous Meteors, 1857–1858;—R. H. Meade, on some Points in the Anatomy of the Araneidea or true Spiders, especially on the internal structure of their Spinning Organs;—W. Fairbairn, Report of the Committee on the Patent Laws;—S. Eddy, on the Lead Mining Districts of Yorkshire;—W. Fairbairn, on the Collapse of Glass Globes and Cylinders;—Dr. E. Perceval Wright and Prof. J. Reåy Greene, Report on the Marine Fauna of the South and West Coasts of Ireland;—Prof. J. Thomson, on Experiments on the Measurement of Water by Triangular Notches in Weir Boards;—Major-General Sabine, Report of the Committee on the Magnetic Survey of Great Britain;—Michael Connel and William Keddie, Report on Animal, Vegetable, and Mineral Substances imported from Foreign Countries into the Clyde (including the Ports of Glasgow, Greenock,

and Port Glasgow) in the years 1853, 1854, 1855, 1856, and 1857;—Report of the Committee on Shipping Statistics;—Rev. H. Lloyd, D.D., Notice of the Instruments employed in the Magnetic Survey of Ireland, with some of the Results;—Prof. J. R. Kinahan, Report of Dublin Dredging Committee, appointed 1857-58;—Prof. J. R. Kinahan, Report on Crustacea of Dublin District;—Andrew Henderson, on River Steamers, their Form, Construction, and Fittings, with reference to the necessity for improving the present means of Shallow-Water Navigation on the Rivers of British India;—George C. Hyndman, Report of the Belfast Dredging Committee;—Appendix to Mr. Vignoles' Paper 'On the Adaptation of Suspension Bridges to sustain the passage of Railway Trains;'—Report of the Joint Committee of the Royal Society and the British Association, for procuring a continuance of the Magnetic and Meteorological Observatories;—R. Beckley, Description of a Self-recording Anemometer.

Together with the Transactions of the Sections, Prof. Owen's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE TWENTY-NINTH MEETING, at Aberdeen, September 1859, *Published at* 15*s.*

CONTENTS:—George C. Foster, Preliminary Report on the Recent Progress and Present State of Organic Chemistry;—Professor Buckman, Report on the Growth of Plants in the Garden of the Royal Agricultural College, Cirencester;—Dr. A. Voelcker, Report on Field Experiments and Laboratory Researches on the Constituents of Manures essential to Cultivated Crops;—A. Thomson, of Banchory, Report on the Aberdeen Industrial Feeding Schools;—On the Upper Silurians of Lesmahagow, Lanarkshire;—Alphonse Gages, Report on the Results obtained by the Mechanico-Chemical Examination of Rocks and Minerals;—William Fairbairn, Experiments to determine the Efficiency of Continuous and Self-acting Brakes for Railway Trains;—Professor J. R. Kinahan, Report of Dublin Bay Dredging Committee for 1858-59;—Rev. Baden Powell, Report on Observations of Luminous Meteors for 1858-59;—Professor Owen, Report on a Series of Skulls of various Tribes of Mankind inhabiting Nepal, collected, and presented to the British Museum, by Bryan H. Hodgson, Esq., late Resident in Nepal, &c. &c.;—Messrs. Maskelyne, Hadow, Hardwich, and Llewelyn, Report on the Present State of our Knowledge regarding the Photographic Image;—G. C. Hyndman, Report of the Belfast Dredging Committee for 1859;—James Oldham, Continuation of Report of the Progress of Steam Navigation at Hull;—Charles Atherton, Mercantile Steam Transport Economy as affected by the Consumption of Coals;—Warren De La Rue, Report on the present state of Celestial Photography in England;—Professor Owen, on the Orders of Fossil and Recent Reptilia, and their Distribution in Time;—Balfour Stewart, on some Results of the Magnetic Survey of Scotland in the years 1857 and 1858, undertaken, at the request of the British Association, by the late John Welsh, Esq., F.R.S.;—W. Fairbairn, The Patent Laws: Report of Committee on the Patent Laws;—J. Park Harrison, Lunar Influence on the Temperature of the Air:—Balfour Stewart, an Account of the Construction of the Self-recording Magnetographs at present in operation at the Kew Observatory of the British Association;—Professor H. J. Stephen Smith, Report on the Theory of Numbers, Part I.;—Report of the Committee on Steamship Performance; —Report of the Proceedings of the Balloon Committee of the British Association appointed at the Meeting at Leeds;—Prof. William K. Sullivan, Preliminary Report on the Solubility of Salts at Temperatures above 100° Cent., and on the Mutual Action of Salts in Solution.

Together with the Transactions of the Sections, Prince Albert's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE THIRTIETH MEETING, at Oxford, June and July 1860, *Published at* 15*s.*

CONTENTS:—James Glaisher, Report on Observations of Luminous Meteors, 1859-60;—J. R. Kinahan, Report of Dublin Bay Dredging Committee;—Rev. J. Anderson, Report on the Excavations in Dura Den;—Prof. Buckman, Report on the Experimental Plots in the Botanical Garden of the Royal Agricultural College, Cirencester;—Rev. R. Walker, Report of the Committee on Balloon Ascents;—Prof. W. Thomson, Report of Committee appointed to prepare a Self-recording Atmo-

spheric Electrometer for Kew, and Portable Apparatus for observing Atmospheric Electricity;—William Fairbairn, Experiments to determine the Effect of Vibratory Action and long-continued Changes of Load upon Wrought-iron Girders;—R. P. Greg, Catalogue of Meteorites and Fireballs, from A.D. 2 to A.D. 1860;—Prof. H. J. S. Smith, Report on the Theory of Numbers, Part II.;—Vice-Admiral Moorsom, on the Performance of Steam-vessels, the Functions of the Screw, and the Relations of its Diameter and Pitch to the Form of the Vessel;—Rev. W. V. Harcourt, Report on the Effects of long-continued Heat, illustrative of Geological Phenomena;—Second Report of the Committee on Steamship Performance;—Interim Report on the Gauging of Water by Triangular Notches;—List of the British Marine Invertebrate Fauna.

Together with the Transactions of the Sections, Lord Wrottesley's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE THIRTY-FIRST MEETING, at Manchester, September 1861, *Published at* £1.

CONTENTS:—James Glaisher, Report on Observations of Luminous Meteors;—Dr. E. Smith, Report on the Action of Prison Diet and Discipline on the Bodily Functions of Prisoners, Part I.;—Charles Atherton, on Freight as affected by Differences in the Dynamic Properties of Steamships;—Warren De La Rue, Report on the Progress of Celestial Photography since the Aberdeen Meeting;—B. Stewart, on the Theory of Exchanges, and its recent extension;—Drs. E. Schunck, R. Angus Smith, and H. E. Roscoe, on the Recent Progress and Present Condition of Manufacturing Chemistry in the South Lancashire District;—Dr. J. Hunt, on Ethno-Climatology; or, the Acclimatization of Man;—Prof. J. Thomson, on Experiments on the Gauging of Water by Triangular Notches;—Dr. A. Voelcker, Report on Field Experiments and Laboratory Researches on the Constituents of Manures essential to cultivated Crops;—Prof. H. Hennessy, Provisional Report on the Present State of our Knowledge respecting the Transmission of Sound-signals during Fogs at Sea;—Dr. P. L. Sclater and F. von Hochstetter, Report on the Present State of our Knowledge of the Birds of the Genus *Apteryx* living in New Zealand;—J. G. Jeffreys, Report of the Results of Deep-sea Dredging in Zetland, with a Notice of several Species of Mollusca new to Science or to the British Isles;—Prof. J. Phillips, Contributions to a Report on the Physical Aspect of the Moon;—W. R. Birt, Contribution to a Report on the Physical Aspect of the Moon;—Dr. Collingwood and Mr. Byerley, Preliminary Report of the Dredging Committee of the Mersey and Dee;—Third Report of the Committee on Steamship Performance;—J. G. Jeffreys, Preliminary Report on the Best Mode of preventing the Ravages of *Teredo* and other Animals in our Ships and Harbours;—R. Mallet, Report on the Experiments made at Holyhead to ascertain the Transit-Velocity of Waves, analogous to Earthquake Waves, through the local Rock Formations;—T. Dobson, on the Explosions in British Coal-Mines during the year 1859;—J. Oldham, Continuation of Report on Steam Navigation at Hull;—Prof. G. Dickie, Brief Summary of a Report on the Flora of the North of Ireland;—Prof. Owen, on the Psychical and Physical Characters of the Mincopies, or Natives of the Andaman Islands, and on the Relations thereby indicated to other Races of Mankind;—Colonel Sykes, Report of the Balloon Committee;—Major-General Sabine, Report on the Repetition of the Magnetic Survey of England;—Interim Report of the Committee for Dredging on the North and East Coasts of Scotland;—W. Fairbairn, on the Resistance of Iron Plates to Statical Pressure and the Force of Impact by Projectiles at High Velocities;—W. Fairbairn, Continuation of Report to determine the effect of Vibratory Action and long-continued Changes of Load upon Wrought-Iron Girders;—Report of the Committee on the Law of Patents;—Prof. H. J. S. Smith, Report on the Theory of Numbers, Part III.

Together with the Transactions of the Sections, Mr. Fairbairn's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE THIRTY-SECOND MEETING at Cambridge, October 1862, *Published at* £1.

CONTENTS:—James Glaisher, Report on Observations of Luminous Meteors, 1861–62;—G. B. Airy, on the Strains in the Interior of Beams;—Archibald Smith and F. J. Evans, Report on the three Reports of the Liverpool Compass Committee;—Report on Tidal Observations on the Humber;—T. Aston, on Rifled Guns and Projectiles

adapted for Attacking Armour-plate Defences;—Extracts, relating to the Observatory at Kew, from a Report presented to the Portuguese Government, by Dr. J. A. de Souza;—H. T. Mennell, Report on the Dredging of the Northumberland Coast and Dogger Bank;—Dr. Cuthbert Collingwood, Report upon the best means of advancing Science through the agency of the Mercantile Marine;—Messrs. Williamson, Wheatstone, Thomson, Miller, Matthiessen, and Jenkin, Provisional Report on Standards of Electrical Resistance;—Preliminary Report of the Committee for investigating the Chemical and Mineralogical Composition of the Granites of Donegal;—Prof. H. Hennessy, on the Vertical Movements of the Atmosphere considered in connection with Storms and Changes of Weather;—Report of Committee on the application of Gauss's General Theory of Terrestrial Magnetism to the Magnetic Variations;—Fleeming Jenkin, on Thermo-electric Currents in Circuits of one Metal;—W. Fairbairn, on the Mechanical Properties of Iron Projectiles at High Velocities;—A. Cayley, Report on the Progress of the Solution of certain Special Problems of Dynamics;—Prof. G. G. Stokes, Report on Double Refraction;—Fourth Report of the Committee on Steamship Performance;—G. J. Symons, on the Fall of Rain in the British Isles in 1860 and 1861;—J. Ball, on Thermometric Observations in the Alps;—J. G. Jeffreys, Report of the Committee for Dredging on the North and East Coasts of Scotland;—Report of the Committee on Technical and Scientific Evidence in Courts of Law;—James Glaisher, Account of Eight Balloon Ascents in 1862;—Prof. H. J. S. Smith, Report on the Theory of Numbers, Part IV.

Together with the Transactions of the Sections, the Rev. Prof. R. Willis's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE THIRTY-THIRD MEETING, at Newcastle-upon-Tyne, August and September 1863, *Published at* £1 5s.

CONTENTS:—Report of the Committee on the Application of Gun-cotton to Warlike Purposes;—A. Matthiessen, Report on the Chemical Nature of Alloys;—Report of the Committee on the Chemical and Mineralogical Constitution of the Granites of Donegal, and on the Rocks associated with them;—J. G. Jeffreys, Report of the Committee appointed for exploring the Coasts of Shetland by means of the Dredge;—G. D. Gibb, Report on the Physiological Effects of the Bromide of Ammonium;—C. K. Aken, on the Transmutation of Spectral Rays, Part I.;—Dr. Robinson, Report of the Committee on Fog Signals;—Report of the Committee on Standards of Electrical Resistance;—E. Smith, Abstract of Report by the Indian Government on the Foods used by the Free and Jail Populations in India;—A. Gages, Synthetical Researches on the Formation of Minerals, &c.;—R. Mallet, Preliminary Report on the Experimental Determination of the Temperatures of Volcanic Foci, and of the Temperature, State of Saturation, and Velocity of the issuing Gases and Vapours;—Report of the Committee on Observations of Luminous Meteors;—Fifth Report of the Committee on Steamship Performance;—G. J. Allman, Report on the Present State of our Knowledge of the Reproductive System in the Hydroida;—J. Glaisher, Account of Five Balloon Ascents made in 1863;—P. P. Carpenter, Supplementary Report on the Present State of our Knowledge with regard to the Mollusca of the West Coast of North America;—Prof. Airy, Report on Steam Boiler Explosions;—C. W. Siemens, Observations on the Electrical Resistance and Electrification of some Insulating Materials under Pressures up to 300 Atmospheres;—C. M. Palmer, on the Construction of Iron Ships and the Progress of Iron Shipbuilding on the Tyne, Wear, and Tees;—Messrs. Richardson, Stevenson, and Clapham, on the Chemical Manufactures of the Northern Districts;—Messrs. Sopwith and Richardson, on the Local Manufacture of Lead, Copper, Zinc, Antimony, &c.;—Messrs. Daglish and Forster, on the Magnesian Limestone of Durham;—I. L. Bell, on the Manufacture of Iron in connection with the Northumberland and Durham Coal-field;—T. Spencer, on the Manufacture of Steel in the Northern District;—Prof. H. J. S. Smith, Report on the Theory of Numbers, Part V.

Together with the Transactions of the Sections, Sir William Armstrong's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE THIRTY-FOURTH MEETING, at Bath, September 1864, *Published at* 18s.

CONTENTS:—Report of the Committee for Observations of Luminous Meteors;—Report of the Committee on the best means of providing for a Uniformity of Weights

and Measures;—T. S. Cobbold, Report of Experiments respecting the Development and Migration of the Entozoa;—B. W. Richardson, Report on the Physiological Action of Nitrite of Amyl;—J. Oldham, Report of the Committee on Tidal Observations;—G. S. Brady, Report on Deep-sea Dredging on the Coasts of Northumberland and Durham in 1864;—J. Glaisher, Account of Nine Balloon Ascents made in 1863 and 1864;—J. G. Jeffreys, Further Report on Shetland Dredgings;—Report of the Committee on the Distribution of the Organic Remains of the North Staffordshire Coal-field;—Report of the Committee on Standards of Electrical Resistance;—G. J. Symons, on the Fall of Rain in the British Isles in 1862 and 1863;—W. Fairbairn, Preliminary Investigation of the Mechanical Properties of the proposed Atlantic Cable.

Together with the Transactions of the Sections, Sir Charles Lyell's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE THIRTY-FIFTH MEETING, at Birmingham, September 1865, *Published at* £1 5*s*.

CONTENTS:—J. G. Jeffreys, Report on Dredging among the Channel Isles;—F. Buckland, Report on the Cultivation of Oysters by Natural and Artificial Methods;—Report of the Committee for exploring Kent's Cavern;—Report of the Committee on Zoological Nomenclature;—Report on the Distribution of the Organic Remains of the North Staffordshire Coal-field;—Report on the Marine Fauna and Flora of the South Coast of Devon and Cornwall;—Interim Report on the Resistance of Water to Floating and Immersed Bodies;—Report on Observations of Luminous Meteors;—Report on Dredging on the Coast of Aberdeenshire;—J. Glaisher, Account of Three Balloon Ascents;—Interim Report on the Transmission of Sound under Water;—G. J. Symons, on the Rainfall of the British Isles;—W. Fairbairn, on the Strength of Materials considered in relation to the Construction of Iron Ships;—Report of the Gun-Cotton Committee;—A. F. Osler, on the Horary and Diurnal Variations in the Direction and Motion of the Air at Wrottesley, Liverpool, and Birmingham;—B. W. Richardson, Second Report on the Physiological Action of certain of the Amyl Compounds;—Report on further Researches in the Lingula-flags of South Wales;—Report of the Lunar Committee for Mapping the Surface of the Moon;—Report on Standards of Electrical Resistance;—Report of the Committee appointed to communicate with the Russian Government respecting Magnetical Observations at Tiflis;—Appendix to Report on the Distribution of the Vertebrate Remains from the North Staffordshire Coal-field;—H. Woodward, First Report on the Structure and Classification of the Fossil Crustacea;—Prof. H. J. S. Smith, Report on the Theory of Numbers, Part VI.;—Report on the best means of providing for a Uniformity of Weights and Measures, with reference to the interests of Science:—A. G. Findlay, on the Bed of the Ocean;—Prof. A. W. Williamson, on the Composition of Gases evolved by the Bath Spring called King's Bath.

Together with the Transactions of the Sections, Prof. Phillips's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE THIRTY-SIXTH MEETING, at Nottingham, August 1866, *Published at* £1 4*s*.

CONTENTS:—Second Report on Kent's Cavern, Devonshire;—A. Matthiessen, Preliminary Report on the Chemical Nature of Cast Iron;—Report on Observations of Luminous Meteors;—W. S. Mitchell, Report on the Alum Bay Leaf-bed;—Report on the Resistance of Water to Floating and Immersed Bodies;—Dr. Norris, Report on Muscular Irritability;—Dr. Richardson, Report on the Physiological Action of certain compounds of Amyl and Ethyl;—H. Woodward, Second Report on the Structure and Classification of the Fossil Crustacea;—Second Report on the 'Menevian Group,' and the other Formations at St. David's, Pembrokeshire;—J. G. Jeffreys, Report on Dredging among the Hebrides;—Rev. A. M. Norman, Report on the Coasts of the Hebrides, Part II.;—J. Alder, Notices of some Invertebrata, in connection with Mr. Jeffreys's Report;—G. S. Brady, Report on the *Ostracoda* dredged amongst the Hebrides;—Report on Dredging in the Moray Firth;—Report on the Transmission of Sound-Signals under Water;—Report of the Lunar Committee;—Report of the Rainfall Committee;—Report on the best means of providing for a Uniformity of Weights and Measures, with reference to the Interests

of Science ;—J. Glaisher, Account of Three Balloon Ascents ;—Report on the Extinct Birds of the Mascarene Islands ;—Report on the Penetration of Ironclad Ships by Steel Shot ;—J. A. Wanklyn, Report on Isomerism among the Alcohols ;—Report on Scientific Evidence in Courts of Law ;—A. L. Adams, Second Report on Maltese Fossiliferous Caves, &c.

Together with the Transactions of the Sections, Mr. Grove's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE THIRTY-SEVENTH MEETING, at Dundee, September 1867, *Published at* £1 6*s*.

CONTENTS :—Report of the Committee for Mapping the Surface of the Moon ;—Third Report on Kent's Cavern, Devonshire ;—On the present State of the Manufacture of Iron in Great Britain ;—Third Report on the Structure and Classification of the Fossil Crustacea ;—Report on the Physiological Action of the Methyl Compounds ;—Preliminary Report on the Exploration of the Plant-Beds of North Greenland ;—Report of the Steamship Performance Committee ;—On the Meteorology of Port Louis, in the Island of Mauritius ;—On the Construction and Works of the Highland Railway ;—Experimental Researches on the Mechanical Properties of Steel ;—Report on the Marine Fauna and Flora of the South Coast of Devon and Cornwall ;—Supplement to a Report on the Extinct Didine Birds of the Mascarene Islands ;—Report on Observations of Luminous Meteors ;—Fourth Report on Dredging among the Shetland Isles ;—Preliminary Report on the Crustacea, &c., procured by the Shetland Dredging Committee in 1867 ;—Report on the Foraminifera obtained in the Shetland Seas ;—Second Report of the Rainfall Committee ;—Report on the best means of providing for a Uniformity of Weights and Measures, with reference to the interests of Science ;—Report on Standards of Electrical Resistance.

Together with the Transactions of the Sections, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE THIRTY-EIGHTH MEETING, at Norwich, August 1868, *Published at* £1 5*s*.

CONTENTS :—Report of the Lunar Committee ;—Fourth Report on Kent's Cavern, Devonshire ;—On Puddling Iron ;—Fourth Report on the Structure and Classification of the Fossil Crustacea ;—Report on British Fossil Corals ;—Report on Spectroscopic Investigations of Animal Substances ;—Report of Steamship Performance Committee ;—Spectrum Analysis of the Heavenly Bodies ;—On Stellar Spectrometry ;—Report on the Physiological Action of the Methyl and allied Compounds ;—Report on the Action of Mercury on the Biliary Secretion ;—Last Report on Dredging among the Shetland Isles ;—Reports on the Crustacea, &c., and on the Annelida and Foraminifera from the Shetland Dredgings ;—Report on the Chemical Nature of Cast Iron, Part I. ;—Interim Report on the Safety of Merchant Ships and their Passengers ;—Report on Observations of Luminous Meteors ;—Preliminary Report on Mineral Veins containing Organic Remains ;—Report on the Desirability of Explorations between India and China ;—Report of Rainfall Committee ;—Report on Synthetical Researches on Organic Acids ;—Report on Uniformity of Weights and Measures ;—Report of the Committee on Tidal Observations ;—Report of the Committee on Underground Temperature ;—Changes of the Moon's Surface ;—Report on Polyatomic Cyanides.

Together with the Transactions of the Sections, Dr. Hooker's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE THIRTY-NINTH MEETING, at Exeter, August 1869, *Published at* £1 2*s*.

CONTENTS :—Report on the Plant-beds of North Greenland ;—Report on the existing knowledge on the Stability, Propulsion, and Seagoing qualities of Ships ;—Report on Steam-boiler Explosions ;—Preliminary Report on the Determination of the Gases existing in Solution in Well-waters ;—The Pressure of Taxation on Real Property ;—On the Chemical Reactions of Light discovered by Prof. Tyndall ;—On Fossils obtained at Kiltorkan Quarry, co. Kilkenny ;—Report of the Lunar Com-

mittee ;—Report on the Chemical Nature of Cast Iron ;—Report on the Marine Fauna and Flora of the South Coast of Devon and Cornwall ;—Report on the Practicability of establishing a 'Close Time' for the Protection of Indigenous Animals ;—Experimental Researches on the Mechanical Properties of Steel ;—Second Report on British Fossil Corals ;—Report of the Committee appointed to get cut and prepared Sections of Mountain-Limestone Corals for Photographing ;—Report on the Rate of Increase of Underground Temperature ;—Fifth Report on Kent's Cavern, Devonshire ;—Report on the Connection between Chemical Constitution and Physiological Action ;—On Emission, Absorption, and Reflection of Obscure Heat ;—Report on Observations of Luminous Meteors ;—Report on Uniformity of Weights and Measures ; —Report on the Treatment and Utilization of Sewage ;—Supplement to Second Report of the Steamship-Performance Committee ;—Report on Recent Progress in Elliptic and Hyperelliptic Functions ;—Report on Mineral Veins in Carboniferous Limestone and their Organic Contents ;—Notes on the Foraminifera of Mineral Veins and the Adjacent Strata ;—Report of the Rainfall Committee ;—Interim Report on the Laws of the Flow and Action of Water containing Solid Matter in Suspension ;—Interim Report on Agricultural Machinery ;—Report on the Physiological Action of Methyl and Allied Series ;—On the Influence of Form considered in Relation to the Strength of Railway-axles and other portions of Machinery subjected to Rapid Alterations of Strain ;—On the Penetration of Armour-plates with Long Shells of Large Capacity fired obliquely ;—Report on Standards of Electrical Resistance.

Together with the Transactions of the Sections, Prof. Stokes's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE FORTIETH MEETING, at Liverpool, September 1870, *Published at* 18*s*.

CONTENTS :—Report on Steam-boiler Explosions ;—Report of the Committee on the Hæmatite Iron-ores of Great Britain and Ireland ;—Report on the Sedimentary Deposits of the River Onny ;—Report on the Chemical Nature of Cast Iron ;—Report on the practicability of establishing a 'Close Time' for the protection of Indigenous Animals ;—Report on Standards of Electrical Resistance ;—Sixth Report on Kent's Cavern ;—Third Report on Underground Temperature ;—Second Report of the Committee appointed to get cut and prepared Sections of Mountain-Limestone Corals ;—Second Report on the Stability, Propulsion, and Seagoing Qualities of Ships ;—Report on Earthquakes in Scotland ;—Report on the Treatment and Utilization of Sewage ;—Report on Observations of Luminous Meteors, 1869–70 ;—Report on Recent Progress in Elliptic and Hyperelliptic Functions ;—Report on Tidal Observations ;—On a new Steam-power Meter ;—Report on the Action of the Methyl and Allied Series ;—Report of the Rainfall Committee ;—Report on the Heat generated in the Blood in the Process of Arterialization ;—Report on the best means of providing for Uniformity of Weights and Measures.

Together with the Transactions of the Sections, Prof. Huxley's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE FORTY-FIRST MEETING, at Edinburgh, August 1871, *Published at* 16*s*.

CONTENTS :—Seventh Report on Kent's Cavern ;—Fourth Report on Underground Temperature ;—Report on Observations of Luminous Meteors, 1870–71 ;—Fifth Report on the Structure and Classification of the Fossil Crustacea ;—Report of the Committee appointed for the purpose of urging on Her Majesty's Government the expediency of arranging and tabulating the results of the approaching Census in the three several parts of the United Kingdom in such a manner as to admit of ready and effective comparison ;—Report of the Committee appointed for the purpose of Superintending the Publication of Abstracts of Chemical Papers ;—Report of the Committee for discussing Observations of Lunar Objects suspected of change ;—Second Provisional Report on the Thermal Conductivity of Metals ;—Report on the Rainfall of the British Isles ;—Third Report on the British Fossil Corals ;—Report on the Heat generated in the Blood during the Process of Arterialization ; —Report of the Committee appointed to consider the subject of Physiological

Experimentation;—Report on the Physiological Action of Organic Chemical Compounds;—Report of the Committee appointed to get cut and prepared Sections of Mountain-Limestone Corals;—Second Report on Steam-Boiler Explosions;—Report on the Treatment and Utilization of Sewage;—Report on promoting the Foundation of Zoological Stations in different parts of the World;—Preliminary Report on the Thermal Equivalents of the Oxides of Chlorine;—Report on the practicability of establishing a 'Close Time' for the protection of Indigenous Animals;—Report on Earthquakes in Scotland;—Report on the best means of providing for a Uniformity of Weights and Measures;—Report on Tidal Observations.

Together with the Transactions of the Sections, Sir William Thomson's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE FORTY-SECOND MEETING, at Brighton, August 1872, *Published at* £1 4*s*.

CONTENTS :—Report on the Gaussian Constants for the Year 1829;—Second Supplementary Report on the Extinct Birds of the Mascarene Islands;—Report of the Committee for Superintending the Monthly Reports of the Progress of Chemistry;—Report of the Committee on the best means of providing for a Uniformity of Weights and Measures;—Eighth Report on Kent's Cavern;—Report on promoting the Foundation of Zoological Stations in different parts of the World;—Fourth Report on the Fauna of South Devon;—Preliminary Report of the Committee appointed to Construct and Print Catalogues of Spectral Rays arranged upon a Scale of Wave-numbers;—Third Report on Steam-Boiler Explosions;—Report on Observations of Luminous Meteors, 1871–72;—Experiments on the Surface-friction experienced by a Plane moving through Water;—Report of the Committee on the Antagonism between the Action of Active Substances;—Fifth Report on Underground Temperature;—Preliminary Report of the Committee on Siemens's Electrical-Resistance Pyrometer;—Fourth Report on the Treatment and Utilization of Sewage;—Interim Report of the Committee on Instruments for Measuring the Speed of Ships and Currents;—Report on the Rainfall of the British Isles;—Report of the Committee on a Geographical Exploration of the Country of Moab;—Sur l'élimination des Fonctions Arbitraires;—Report on the Discovery of Fossils in certain remote parts of the North-western Highlands;—Report of the Committee on Earthquakes in Scotland;—Fourth Report on Carboniferous-Limestone Corals;—Report of the Committee to consider the mode in which new Inventions and Claims for Reward in respect of adopted Inventions are examined and dealt with by the different Departments of Government;—Report of the Committee for discussing Observations of Lunar Objects suspected of change;—Report on the Mollusca of Europe;—Report of the Committee for investigating the Chemical Constitution and Optical Properties of Essential Oils;—Report on the practicability of establishing a 'Close Time' for the preservation of Indigenous Animals;—Sixth Report on the Structure and Classification of Fossil Crustacea;—Report of the Committee appointed to organize an Expedition for observing the Solar Eclipse of Dec. 12, 1871;—Preliminary Report of a Committee on Terato-embryological Inquiries;—Report on Recent Progress in Elliptic and Hyperelliptic Functions;—Report on Tidal Observations;—On the Brighton Waterworks;—On Amsler's Planimeter.

Together with the Transactions of the Sections, Dr. Carpenter's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE FORTY-THIRD MEETING, at Bradford, September 1873, *Published at* £1 5*s*.

CONTENTS :—Report of the Committee on Mathematical Tables;—Observations on the Application of Machinery to the Cutting of Coal in Mines;—Concluding Report on the Maltese Fossil Elephants;—Report of the Committee for ascertaining the Existence in different parts of the United Kingdom of any Erratic Blocks or Boulders;—Fourth Report on Earthquakes in Scotland;—Ninth Report on Kent's Cavern;—On the Flint and Chert Implements found in Kent's Cavern;—Report of the Committee for Investigating the Chemical Constitution and Optical Properties of Essential Oils;—Report of Inquiry into the Method of making Gold-assays;

—Fifth Report on the Selection and Nomenclature of Dynamical and Electrical Units ;—Report of the Committee on the Labyrinthodonts of the Coal-measures ;—Report of the Committee appointed to construct and print Catalogues of Spectral Rays ;—Report of the Committee appointed to explore the Settle Caves ;—Sixth Report on Underground Temperature ;—Report on the Rainfall of the British Isles ;—Seventh Report on Researches in Fossil Crustacea ;—Report on Recent Progress in Elliptic and Hyperelliptic Functions ;—Report on the desirability of establishing a 'Close Time' for the preservation of Indigenous Animals ;—Report on Luminous Meteors ; —On the Visibility of the Dark Side of Venus ;—Report of the Committee for the Foundation of Zoological Stations in different parts of the World ;—Second Report of the Committee for collecting Fossils from North-western Scotland ;—Fifth Report on the Treatment and Utilization of Sewage ;—Report of the Committee on Monthly Reports of the Progress of Chemistry ;—On the Bradford Waterworks ;—Report on the possibility of Improving the Methods of Instruction in Elementary Geometry ; —Interim Report of the Committee on Instruments for Measuring the Speed of Ships, &c. ;—Report of the Committee for Determinating High Temperatures by means of the Refrangibility of Light evolved by Fluid or Solid Substances ;—On a Periodicity of Cyclones and Rainfall in connection with Sunspot Periodicity ;—Fifth Report on the Structure of Carboniferous-Limestone Corals ;—Report of the Committee on preparing and publishing brief forms of Instructions for Travellers, Ethnologists, &c. ;—Preliminary Note from the Committee on the Influence of Forests on the Rainfall ;—Report of the Sub-Wealden Exploration Committee ;—Report of the Committee on Machinery for obtaining a Record of the Roughness of the Sea and Measurement of Waves near shore ;—Report on Science Lectures and Organization ;—Second Report on Science Lectures and Organization.

Together with the Transactions of the Sections, Prof. A. W. Williamson's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS of the FORTY-FOURTH MEETING, at Belfast, August 1874, *Published at £1 5s.*

Contents :—Tenth Report on Kent's Cavern ;—Report for investigating the Chemical Constitution and Optical Properties of Essential Oils ;—Second Report of the Sub-Wealden Exploration Committee ;—On the Recent Progress and Present State of Systematic Botany ;—Report of the Committee for investigating the Nature of Intestinal Secretion ;—Report of the Committee on the Teaching of Physics in Schools ;—Preliminary Report for investigating Isomeric Cresols and their Derivatives ;—Third Report of the Committee for collecting Fossils from localities in North-western Scotland ;—Report on the Rainfall of the British Isles ;—On the Belfast Harbour ;—Report of Inquiry into the Method of making Gold-assays ;—Report of a Committee on Experiments to determine the Thermal Conductivities of certain Rocks ;—Second Report on the Exploration of the Settle Caves ;—On the Industrial uses of the Upper Bann River ;—Report of the Committee on the Structure and Classification of the Labyrinthodonts ;—Second Report of the Committee for recording the position, height above the sea, lithological characters, size, and origin of the Erratic Blocks of England and Wales, &c. ;—Sixth Report on the Treatment and Utilization of Sewage ;—Report on the Anthropological Notes and Queries for the use of Travellers ;—On Cyclone and Rainfall Periodicities ;—Fifth Report on Earthquakes in Scotland ;—Report of the Committee appointed to prepare and print Tables of Wave-numbers ;—Report of the Committee for testing the new Pyrometer of Mr. Siemens ;—Report to the Lords Commissioners of the Admiralty on Experiments for the Determination of the Frictional Resistance of Water on a Surface &c. ;—Second Report for the Selection and Nomenclature of Dynamical and Electrical Units ;—On Instruments for measuring the Speed of Ships ;—Report of the Committee on the possibility of establishing a 'Close Time' for the Protection of Indigenous Animals ;—Report of the Committee to inquire into the economic effects of Combinations of Labourers and Capitalists ;—Preliminary Report on Dredging on the Coasts of Durham and North Yorkshire ;—Report on Luminous Meteors ;—Report on the best means of providing for a Uniformity of Weights and Measures.

Together with the Transactions of the Sections, Prof. John Tyndall's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE FORTY-FIFTH MEETING, at Bristol, August 1875, *Published at £1 5s.* (Out of Print.)

CONTENTS:—Eleventh Report on Kent's Cavern;—Seventh Report on Underground Temperature;—Report on the Zoological Station at Naples;—Report of a Committee appointed to inquire into the Methods employed in the Estimation of Potash and Phosphoric Acid in Commercial Products;—Report on the present state of our Knowledge of the Crustacea;—Second Report on the Thermal Conductivities of certain Rocks;—Preliminary Report of the Committee for extending the Observations on the Specific Volumes of Liquids;—Sixth Report on Earthquakes in Scotland;—Seventh Report on the Treatment and Utilization of Sewage;—Report of the Committee for furthering the Palestine Explorations;—Third Report of the Committee for recording the position, height above the sea, lithological characters, size, and origin of the Erratic Blocks of England and Wales, &c.;—Report of the Rainfall Committee;—Report of the Committee for investigating Isomeric Cresols and their Derivatives;—Report of the Committee for investigating the Circulation of the Underground Waters in the New Red Sandstone and Permian Formations of England;—On the Steering of Screw-Steamers;—Second Report of the Committee on Combinations of Capital and Labour;—Report on the Method of making Gold-assays;—Eighth Report on Underground Temperature;—Tides in the River Mersey;—Sixth Report of the Committee on the Structure of Carboniferous Corals;—Report of the Committee appointed to explore the Settle Caves;—On the River Avon (Bristol), its Drainage-Area, &c.;—Report of the Committee on the possibility of establishing a 'Close Time' for the Protection of Indigenous Animals;—Report of the Committee appointed to superintend the Publication of the Monthly Reports of the Progress of Chemistry;—Report on Dredging off the Coasts of Durham and North Yorkshire in 1874;—Report on Luminous Meteors;—On the Analytical Forms called Trees;—Report of the Committee on Mathematical Tables;—Report of the Committee on Mathematical Notation and Printing;—Second Report of the Committee for investigating Intestinal Secretion;—Third Report of the Sub-Wealden Exploration Committee.

Together with the Transactions of the Sections, Sir John Hawkshaw's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE FORTY-SIXTH MEETING, at Glasgow, September 1876, *Published at £1 5s.*

CONTENTS:—Twelfth Report on Kent's Cavern;—Report on Improving the Methods of Instruction in Elementary Geometry;—Results of a Comparison of the British-Association Units of Electrical Resistance;—Third Report on the Thermal Conductivities of certain Rocks;—Report of the Committee on the practicability of adopting a Common Measure of Value in the Assessment of Direct Taxation;—Report of the Committee for testing experimentally Ohm's Law;—Report of the Committee on the possibility of establishing a 'Close Time' for the Protection of Indigenous Animals;—Report of the Committee on the Effect of Propellers on the Steering of Vessels;—On the Investigation of the Steering Qualities of Ships;—Seventh Report on Earthquakes in Scotland;—Report on the present state of our Knowledge of the Crustacea;—Second Report of the Committee for investigating the Circulation of the Underground Waters in the New Red Sandstone and Permian Formations of England;—Fourth Report of the Committee on the Erratic Blocks of England and Wales, &c.;—Fourth Report of the Committee on the Exploration of the Settle Caves (Victoria Cave);—Report on Observations of Luminous Meteors, 1875-76;—Report on the Rainfall of the British Isles, 1875-76;—Ninth Report on Underground Temperature;—Nitrous Oxide in the Gaseous and Liquid States;—Eighth Report on the Treatment and Utilization of Sewage;—Improved Investigations on the Flow of Water through Orifices, with Objections to the modes of treatment commonly adopted;—Report of the Anthropometric Committee;—On Cyclone and Rainfall Periodicities in connection with the Sun-spot Periodicity;—Report of the Committee for determining the Mechanical Equivalent of Heat;—Report of the Committee on Tidal Observations;—Third Report of the Committee on the Conditions of Intestinal Secretion and Movement;—Report of the Committee for collecting and suggesting subjects for Chemical Research.

Together with the Transactions of the Sections, Dr. T. Andrews's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE FORTY-SEVENTH MEETING, at Plymouth, August 1877, *Published at* £1 4*s.*

CONTENTS:—Thirteenth Report on Kent's Cavern;—Second and Third Reports on the Methods employed in the estimation of Potash and Phosphoric Acid in Commercial Products;—Report on the present state of our Knowledge of the Crustacea (Part III.);—Third Report on the Circulation of the Underground Waters in the New Red Sandstone and Permian Formations of England;—Fifth Report on the Erratic Blocks of England, Wales, and Ireland;—Fourth Report on the Thermal Conductivities of certain Rocks;—Report on Observations of Luminous Meteors, 1876–77;—Tenth Report on Underground Temperature;—Report on the Effect of Propellers on the Steering of Vessels;—Report on the possibility of establishing a 'Close Time' for the Protection of Indigenous Animals;—Report on some Double Compounds of Nickel and Cobalt;—Fifth Report on the Exploration of the Settle Caves (Victoria Cave);—Report on the Datum Level of the Ordnance Survey of Great Britain;—Report on the Zoological Station at Naples;—Report of the Anthropometric Committee;—Report on the Conditions under which Liquid Carbonic Acid exists in Rocks and Minerals.

Together with the Transactions of the Sections, Prof. Allen Thomson's Address and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE FORTY-EIGHTH MEETING, at Dublin, August 1878, *Published at* £1 4*s.*

CONTENTS:—Catalogue of the Oscillation-Frequencies of Solar Rays;—Report on Mr. Babbage's Analytical Machine;—Third Report of the Committee for determining the Mechanical Equivalent of Heat;—Report of the Committee for arranging for the taking of certain Observations in India, and Observations on Atmospheric Electricity at Madeira;—Report on the commencement of Secular Experiments upon the Elasticity of Wires;—Report on the Chemistry of some of the lesser-known Alkaloids, especially Veratria and Bebeerine;—Report on the best means for the Development of Light from Coal-Gas;—Fourteenth Report on Kent's Cavern;—Report on the Fossils in the North-west Highlands of Scotland;—Fifth Report on the Thermal Conductivities of certain Rocks;—Report on the possibility of establishing a 'Close Time' for the Protection of Indigenous Animals;—Report on the occupation of a Table at the Zoological Station at Naples;—Report of the Anthropometric Committee;—Report on Patent Legislation;—Report on the Use of Steel for Structural Purposes;—Report on the Geographical Distribution of the Chiroptera;—Recent Improvements in the Port of Dublin;—Report on Mathematical Tables;—Eleventh Report on Underground Temperature;—Report on the Exploration of the Fermanagh Caves;—Sixth Report on the Erratic Blocks of England, Wales, and Ireland;—Report on the present state of our Knowledge of the Crustacea (Part IV.);—Report on two Caves in the neighbourhood of Tenby;—Report on the Stationary Tides in the English Channel and in the North Sea, &c.;—Second Report on the Datum-level of the Ordnance Survey of Great Britain;—Report on instruments for measuring the Speed of Ships;—Report of Investigations into a Common Measure of Value in Direct Taxation;—Report on Sunspots and Rainfall;—Report on Observations of Luminous Meteors;—Sixth Report on the Exploration of the Settle Caves (Victoria Cave);—Report on the Kentish Boring Exploration;—Fourth Report on the Circulation of Underground Waters in the Jurassic, New Red Sandstone, and Permian Formations, with an Appendix on the Filtration of Water through Triassic Sandstone;—Report on the Effect of Propellers on the Steering of Vessels.

Together with the Transactions of the Sections, Mr. Spottiswoode's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE FORTY-NINTH MEETING, at Sheffield, August 1879, *Published at* £1 4*s.*

CONTENTS:—Report on the commencement of Secular Experiments upon the Elasticity of Wires;—Fourth Report of the Committee for determining the Mechanical Equivalent of Heat;—Report of the Committee for endeavouring to procure reports on the Progress of the Chief Branches of Mathematics and Physics;—Twelfth

Report on Underground Temperature;—Report on Mathematical Tables;—Sixth Report on the Thermal Conductivities of certain Rocks;—Report on Observations of Atmospheric Electricity at Madeira;—Report on the Calculation of Tables of the Fundamental Invariants of Algebraic Forms;—Report on the Calculation of Sun-Heat Coefficients;—Second Report on the Stationary Tides in the English Channel and in the North Sea, &c.;—Report on Observations of Luminous Meteors;—Report on the question of Improvements in Astronomical Clocks;—Report of the Committee for improving an Instrument for detecting the presence of Fire-damp in Mines;—Report on the Chemistry of some of the lesser-known Alkaloids, especially Veratria and Bebeerine;—Seventh Report on the Erratic Blocks of England, Wales, and Ireland;—Fifteenth Report on Kent's Cavern;—Report on certain Caves in Borneo;—Fifth Report on the Circulation of Underground Waters in the Jurassic, Red Sandstone, and Permian Formations of England;—Report on the Tertiary (Miocene) Flora, &c., of the Basalt of the North of Ireland;—Report on the possibility of Establishing a 'Close Time' for the Protection of Indigenous Animals;—Report on the Marine Zoology of Devon and Cornwall;—Report on the Occupation of a Table at the Zoological Station at Naples;—Report on Excavations at Portstewart and elsewhere in the North of Ireland;—Report of the Anthropometric Committee;—Report on the Investigation of the Natural History of Socotra;—Report on Instruments for measuring the Speed of Ships;—Third Report on the Datum-level of the Ordnance Survey of Great Britain;—Second Report on Patent Legislation;—On Self-acting Intermittent Siphons and the conditions which determine the commencement of their Action;—On some further Evidence as to the Range of the Palæozoic Rocks beneath the South-east of England;—Hydrography, Past and Present.

Together with the Transactions of the Sections, Prof. Allman's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE FIFTIETH MEETING, at Swansea, August and September 1880, *Published at £1 4s.*

CONTENTS:—Report on the Measurement of the Lunar Disturbance of Gravity;—Thirteenth Report on Underground Temperature;—Report of the Committee for devising and constructing an improved form of High Insulation Key for Electrometer Work;—Report on Mathematical Tables;—Report on the Calculation of Tables of the Fundamental Invariants of Algebraic Forms;—Report on Observations of Luminous Meteors;—Report on the question of Improvements in Astronomical Clocks;—Report on the commencement of Secular Experiments on the Elasticity of Wires;—Sixteenth and concluding Report on Kent's Cavern;—Report on the mode of reproduction of certain species of Ichthyosaurus from the Lias of England and Würtemburg;—Report on the Carboniferous Polyzoa;—Report on the 'Geological Record';—Sixth Report on the Circulation of the Underground Waters in the Permian, New Red Sandstone, and Jurassic Formations of England, and the Quantity and Character of the Water supplied to towns and districts from these formations;—Second Report on the Tertiary (Miocene) Flora, &c., of the Basalt of the North of Ireland;—Eighth Report on the Erratic Blocks of England, Wales, and Ireland;—Report on an Investigation for the purpose of fixing a Standard of White Light;—Report of the Anthropometric Committee;—Report on the Influence of Bodily Exercise on the Elimination of Nitrogen;—Second Report on the Marine Zoology of South Devon;—Report on the Occupation of a Table at the Zoological Station at Naples;—Report on accessions to our knowledge of the Chiroptera during the past two years (1878–80);—Preliminary Report on the accurate measurement of the specific inductive capacity of a good Sprengel Vacuum, and the specific resistance of gases at different pressures;—Comparison of Curves of the Declination Magnetographs at Kew, Stonyhurst, Coimbra, Lisbon, Vienna, and St. Petersburg;—First Report on the Caves of the South of Ireland;—Report on the Investigation of the Natural History of Socotra;—Report on the German and other systems of teaching the Deaf to speak;—Report of the Committee for considering whether it is important that H.M. Inspectors of Elementary Schools should be appointed with reference to their ability for examining in the scientific specific subjects of the Code in addition to other matters;—On the Anthracite Coal and Coalfield of South Wales;—Report on the present state of our knowledge of Crustacea (Part V.);—Report on the best means for the Development of Light from Coal-gas of different qualities (Part II.);—Report

on Palæontological and Zoological Researches in Mexico;—Report on the possibility of establishing a 'Close Time' for Indigenous Animals;—Report on the present state of our knowledge of Spectrum Analysis;—Report on Patent Legislation;—Preliminary Report on the present Appropriation of Wages, &c.;—Report on the present state of knowledge of the application of Quadratures and Interpolation to Actual Data;—The French Deep-sea Exploration in the Bay of Biscay;—Third Report on the Stationary Tides in the English Channel and in the North Sea, &c.;—List of Works on the Geology, Mineralogy, and Palæontology of Wales (to the end of 1873):—On the recent Revival in Trade.

Together with the Transactions of the Sections, Dr. A. C. Ramsay's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE FIFTY-FIRST MEETING, at York, August and September 1881, *Published at £1 4s.*

CONTENTS:—Report on the Calculation of Tables of the Fundamental Invariants of Algebraic Forms;—Report on Recent Progress in Hydrodynamics (Part I.);—Report on Meteoric Dust;—Second Report on the Calculation of Sun-heat Coefficients;—Fourteenth Report on Underground Temperature;—Report on the Measurement of the Lunar Disturbance of Gravity;—Second Report on an Investigation for the purpose of fixing a Standard of White Light;—Final Report on the Thermal Conductivities of certain Rocks;—Report on the manner in which Rudimentary Science should be taught, and how Examinations should be held therein, in Elementary Schools;—Third Report on the Tertiary Flora of the North of Ireland;—Report on the Method of Determining the Specific Refraction of Solids from their Solutions;—Fourth Report on the Stationary Tides in the English Channel and in the North Sea, &c.;—Second Report on Fossil Polyzoa;—Report on the Maintenance of the Scottish Zoological Station;—Report on the Occupation of a Table at the Zoological Station at Naples;—Report on the Migration of Birds;—Report on the Natural History of Socotra;—Report on the Natural History of Timor-laut;—Report on the Marine Fauna of the Southern Coast of Devon and Cornwall;—Report on the Earthquake Phenomena of Japan;—Ninth Report on the Erratic Blocks of England, Wales, and Ireland;—Second Report on the Caves of the South of Ireland;—Report on Patent Legislation;—Report of the Anthropometric Committee;—Report on the Appropriation of Wages, &c.;—Report on Observations of Luminous Meteors;—Report on Mathematical Tables;—Seventh Report on the Circulation of Underground Waters in the Jurassic, New Red Sandstone, and Permian Formations of England, and the Quality and Quantity of the Water supplied to Towns and Districts from these Formations;—Report on the present state of our Knowledge of Spectrum Analysis;—Interim Report of the Committee for constructing and issuing practical Standards for use in Electrical Measurements;—On some new Theorems on Curves of Double Curvature;—Observations of Atmospheric Electricity at the Kew Observatory during 1880;—On the Arrestation of Infusorial Life by Solar Light;—On the Effects of Oceanic Currents upon Climates;—On Magnetic Disturbances and Earth Currents;—On some Applications of Electric Energy to Horticultural and Agricultural purposes;—On the Pressure of Wind upon a Fixed Plane Surface;—On the Island of Socotra;—On some of the Developments of Mechanical Engineering during the last Half-Century.

Together with the Transactions of the Sections, Sir John Lubbock's Address, and Recommendations of the Association and its Committees.

REPORT OF THE FIFTY-SECOND MEETING, at Southampton, August 1882, *Published at £1 4s.*

CONTENTS:—Report on the Calculation of Tables of Fundamental Invariants of Binary Quantics;—Report (provisional) of the Committee for co-operating with the Meteorological Society of the Mauritius in their proposed publication of Daily Synoptic Charts of the Indian Ocean from the year 1861;—Report of the Committee appointed for fixing a Standard of White Light;—Report on Recent Progress in Hydrodynamics (Part II.);—Report of the Committee for constructing and issuing practical Standards for use in Electrical Measurements;—Fifteenth Report on Underground Temperature, with Summary of the Results contained in the Fifteen Reports

of the Underground Temperature Committee;—Report on Meteoric Dust;—Second Report on the Measurement of the Lunar Disturbance of Gravity;—Report on the present state of our Knowledge of Spectrum Analysis;—Report on the Investigation by means of Photography of the Ultra-Violet Spark Spectra emitted by Metallic Elements, and their combinations under varying conditions;—Report of the Committee for preparing a new Series of Tables of Wave-lengths of the Spectra of the Elements;—Report on the Methods employed in the Calibration of Mercurial Thermometers;—Second Report on the Earthquake Phenomena of Japan;—Eighth Report on the Circulation of the Underground Waters in the Permeable Formations of England, and the Quality and Quantity of the Water supplied to various Towns and Districts from these Formations;—Report on the Conditions under which ordinary Sedimentary Materials may be converted into Metamorphic Rocks;—Report on Explorations in Caves of Carboniferous Limestone in the South of Ireland;—Report on the Preparation of an International Geological Map of Europe;—Tenth Report on the Erratic Blocks of England, Wales, and Ireland;—Report on Fossil Polyzoa (Jurassic Species—British Area only);—Preliminary Report on the Flora of the 'Halifax Hard Bed,' Lower Coal Measures;—Report on the Influence of Bodily Exercise on the Elimination of Nitrogen;—Report of the Committee appointed for obtaining Photographs of the Typical Races in the British Isles;—Preliminary Report on the Ancient Earthwork in Epping Forest known as the Loughton Camp;—Second Report on the Natural History of Timor-laut;—Report of the Committee for carrying out the recommendations of the Anthropometric Committee of 1880, especially as regards the anthropometry of children and of females, and the more complete discussion of the collected facts;—Report on the Natural History of Socotra and the adjacent Highlands of Arabia and Somali Land;—Report on the Maintenance of the Scottish Zoological Station;—Report on the Migration of Birds;—Report on the Occupation of a Table at the Zoological Station at Naples;—Report on the Survey of Eastern Palestine;—Final Report on the Appropriation of Wages, &c.;—Report on the working of the revised New Code, and of other legislation affecting the teaching of Science in Elementary Schools;—Report on Patent Legislation;—Report of the Committee for determining a Gauge for the manufacture of various small Screws;—Report on the best means of ascertaining the Effective Wind Pressure to which buildings and structures are exposed;—On the Boiling Points and Vapour Tension of Mercury, of Sulphur, and of some Compounds of Carbon, determined by means of the Hydrogen Thermometer;—On the Method of Harmonic Analysis used in deducing the Numerical Values of the Tides of long period, and on a Misprint in the Tidal Report for 1872;—List of Works on the Geology and Palæontology of Oxfordshire, of Berkshire, and of Buckinghamshire;—Notes on the oldest Records of the Sea-Route to China from Western Asia;—The Deserts of Africa and Asia;—State of Crime in England, Scotland, and Ireland in 1880;—On the Treatment of Steel for the Construction of Ordnance, and other purposes;—The Channel Tunnel;—The Forth Bridge.

Together with the Transactions of the Sections, Dr. C. W. Siemens's Address, and Recommendations of the Association and its Committees.

REPORT OF THE FIFTY-THIRD MEETING, at Southport, September 1883, *Published at £1 4s.*

CONTENTS:—Report of the Committee for constructing and issuing practical Standards for use in Electrical Measurements;—Sixteenth Report on Underground Temperature;—Report on the best Experimental Methods that can be used in observing Total Solar Eclipses;—Report on the Harmonic Analysis of Tidal Observations;—Report of the Committee for co-operating with the Meteorological Society of the Mauritius in their proposed publication of Daily Synoptic Charts of the Indian Ocean from the year 1861;—Report on Mathematical Tables;—Report of the Committee for co-operating with the Scottish Meteorological Society in making Meteorological Observations on Ben Nevis;—Report on Meteoric Dust;—Report of the Committee appointed for fixing a Standard of White Light;—Report on Chemical Nomenclature;—Report on the investigation by means of Photography of the Ultra-Violet Spark Spectra emitted by Metallic Elements, and their combinations under varying conditions;—Report on Isomeric Naphthalene Derivatives;—Report on Explorations in Caves in the Carboniferous Limestone in the South of Ireland;—Report on the Exploration of Raygill Fissure, Yorkshire;—Eleventh Report on the

Erratic Blocks of England, Wales, and Ireland ;—Ninth Report on the Circulation of the Underground Waters in the Permeable Formations of England, and the Quality and Quantity of the Water supplied to various Towns and Districts from these Formations ;—Report on the Fossil Plants of Halifax ;—Fourth Report on Fossil Polyzoa ;—Fourth Report on the Tertiary Flora of the North of Ireland ;—Report on the Earthquake Phenomena of Japan ;—Report on the Fossil Phyllopoda of the Palæozoic Rocks ;—Third Report on the Natural History of Timor Laut ;—Report on the Natural History of Socotra and the adjacent Highlands of Arabia and Somali Land ;—Report on the Exploration of Kilima-njaro and the adjoining mountains of Eastern Equatorial Africa ;—Report on the Migration of Birds ;—Report on the Maintenance of the Scottish Zoological Station ;—Report on the Occupation of a Table at the Zoological Station at Naples ;—Report on the Influence of Bodily Exercise on the Elimination of Nitrogen ;—Report on the Ancient Earthwork in Epping Forest, known as the 'Loughton' or 'Cowper's' Camp ;—Final Report of the Anthropometric Committee ;—Report of the Committee for defining the Facial Characteristics of the Races and Principal Crosses in the British Isles, and obtaining Illustrative Photographs ;—Report on the Survey of Eastern Palestine ;—Report on the workings of the proposed revised New Code, and of other legislation affecting the teaching of Science in Elementary Schools ;—Report on Patent Legislation ;—Report of the Committee for determining a Gauge for the manufacture of various small Screws ;—Report of the 'Local Scientific Societies' Committee ;—On some results of photographing the Solar Corona without an Eclipse ;—On Lamé's Differential Equation ;—Recent Changes in the Distribution of Wealth in relation to the Incomes of the Labouring Classes ;—On the Mersey Tunnel ;—On Manganese Bronze ;—Nest Gearing.

Together with the Transactions of the Sections, Professor Cayley's Address, and Recommendations of the Association and its Committees.

REPORT OF THE FIFTY-FOURTH MEETING, at Montreal, August and September, 1884, *Published at* 1*l.* 4*s.*

CONTENTS :—Report of the Committee for considering and advising on the best means for facilitating the adoption of the Metric System of Weights and Measures in Great Britain ;—Report of the Committee for considering the best methods of recording the direct intensity of Solar Radiation ;—Report of the Committee for constructing and issuing practical Standards for use in Electrical Measurements ;—Report of the Committee for co-operating with the Meteorological Society of the Mauritius, in their proposed publication of Daily Synoptic Charts of the Indian Ocean from the year 1861 ;—Second Report on the Harmonic Analysis of Tidal Observations ;—Report of the Committee for co-operating with Mr. E. J. Lowe in his project of establishing a Meteorological Observatory near Chepstow on a permanent and scientific basis ;—Report of the Committee for co-operating with the Directors of the Ben Nevis Observatory in making Meteorological Observations on Ben Nevis ;—Report of the Committee for reducing and tabulating the Tidal Observations in the English Channel, made with the Dover Tide-gauge, and for connecting them with Observations made on the French Coast ;—Fourth Report on Meteoric Dust ;—Second Report on Chemical Nomenclature ;—Report on Isomeric Naphthalene Derivatives ;—Second Report on the Fossil Phyllopoda of the Palæozoic Rocks ;—Tenth Report on the Circulation of Underground Waters in the Permeable Formations of England and Wales, and the Quantity and Character of the Water supplied to various Towns and Districts from these Formations ;—Fifth and last Report on Fossil Polyzoa ;—Twelfth Report on the Erratic Blocks of England, Wales, and Ireland ;—Report upon the National Geological Surveys of Europe ;—Report on the Rate of Erosion of the Sea-coasts of England and Wales, and the Influence of the Artificial Abstraction of Shingle or other material in that action ;—Report on the Exploration of the Raygill Fissure in Lothersdale, Yorkshire ;—Fourth Report on the Earthquake Phenomena of Japan ;—Report on the occupation of a Table at the Zoological Station at Naples ;—Fourth Report on the Natural History of Timor Laut ;—Report on the Influence of Bodily Exercise on the Elimination of Nitrogen ;—Report on the Migration of Birds ;—Report on the Preparation of a Bibliography of certain groups of Invertebrata ;—Report on the Exploration of Kilima-njaro, and the adjoining mountains of Eastern Equatorial Africa ;—Report on the Survey of Eastern Palestine ;—Report of the Committee for defraying the expenses of completing the Preparation of the final Report of the Anthropometric Committee ;—Report on the

teaching of Science in Elementary Schools;—Report of the Committee for determining a Gauge for the manufacture of the various small Screws used in Telegraphic and Electrical Apparatus, in Clockwork, and for other analogous purposes;—Report on Patent Legislation;—Report of the Committee for defining the Facial Characteristics of the Races and Principal Crosses in the British Isles, and obtaining Illustrative Photographs with a view to their publication;—Report on the present state of our knowledge of Spectrum Analysis;—Report of the Committee for preparing a new series of Wave-length Tables of the Spectra of the Elements;—On the Connection between Sunspots and Terrestrial Phenomena;—On the Seat of the Electromotive Forces in the Voltaic Cell;—On the Archæan Rocks of Great Britain;—On the Concordance of the Mollusca inhabiting both sides of the North Atlantic and the intermediate Seas;—On the Characteristics of the North American Flora;—On the Theory of the Steam Engine;—Improvements in Coast Signals, with Supplementary Remarks on the New Eddystone Lighthouse;—On American Permanent Way.

Together with the Transactions of the Sections, Lord Rayleigh's Address, and Recommendations of the Association and its Committees.

REPORT OF THE FIFTY-FIFTH MEETING, at Aberdeen, September 1885, *Published at* £1 4*s.*

CONTENTS:—Report of the Committee for constructing and issuing practical Standards for use in Electrical Measurements;—Report of the Committee for promoting Tidal Observations in Canada;—Fifth Report on Meteoric Dust;—Third Report on the Harmonic Analysis of Tidal Observations;—Report of the Committee for co-operating with the Meteorological Society of the Mauritius in their proposed publication of Daily Synoptic Charts of the Indian Ocean from the year 1861;—Report of the Committee for reducing and tabulating the Tidal Observations in the English Channel, made with the Dover Tide-gauge, and for connecting them with Observations made on the French Coast;—Report on Standards of White Light;—Report of the Committee for co-operating with Mr. E. J. Lowe in his project of establishing a Meteorological Observatory near Chepstow on a permanent and scientific basis;—Report on the best means of Comparing and Reducing Magnetic Observations;—Report of the Committee for co-operating with the Scottish Meteorological Society in making Meteorological Observations on Ben Nevis;—Seventeenth Report on Underground Temperature;—Report on Electrical Theories;—Second Report of the Committee for considering the best methods of recording the direct intensity of Solar Radiation;—Report on Optical Theories;—Report of the Committee for investigating certain Physical Constants of Solution, especially the Expansion of Saline Solutions;—Third Report on Chemical Nomenclature;—Report of the Committee for the Investigation by means of Photography of the Ultra-Violet Spark Spectra emitted by Metallic Elements and their Combinations under varying conditions;—Report of the Committee for investigating the subject of Vapour Pressures and Refractive Indices of Salt Solutions;—Report of the Committee for preparing a new series of Wave-length Tables of the Spectra of the Elements and Compounds;—Thirteenth Report on the Erratic Blocks of England, Wales, and Ireland;—Third Report on the Fossil Phyllopoda of the Palæozoic Rocks;—Fifth Report on the Earthquake Phenomena of Japan;—Eleventh Report on the Circulation of Underground Waters in the Permeable Formations of England and Wales, and the Quantity and Character of the Water supplied to various Towns and Districts from these Formations;—Report on the Volcanic Phenomena of Vesuvius;—Report on the Fossil Plants of the Tertiary and Secondary Beds of the United Kingdom;—Report on the Rate of Erosion of the Sea-coasts of England and Wales, and the Influence of the Artificial Abstraction of Shingle or other material in that action;—Report on the occupation of a Table at the Zoological Station at Naples;—Report of the Committee for promoting the Establishment of a Marine Biological Station at Granton, Scotland;—Report on the Aid given by the Dominion Government and the Government of the United States to the Encouragement of Fisheries, and to the Investigation of the various forms of Marine Life on the coasts and rivers of North America;—Report of the Committee for promoting the Establishment of Marine Biological Stations on the coast of the United Kingdom;—Report on recent Polyzoa;—Third Report on the Exploration of Kilima-njaro and the adjoining mountains of Equatorial Africa;—Report on the Migration of Birds;—Report of the Committee for furthering the

Exploration of New Guinea by making a grant to Mr. Forbes for the purposes of his Expedition;—Report of the Committee for furthering the Scientific Examination of the country in the vicinity of Mount Roraima in Guiana by making a grant to Mr. Everard F. im Thurn for the purposes of his Expedition;—Report of the Committee for promoting the Survey of Palestine;—Report on the Teaching of Science in Elementary Schools;—Report on Patent Legislation;—Report of the Committee for investigating and publishing reports on the physical characters, languages, and industrial and social condition of the North-Western Tribes of the Dominion of Canada;—Report of the Corresponding Societies Committee;—On Electrolysis;—A tabular statement of the dates at which, and the localities where Pumice or Volcanic Dust was seen in the Indian Ocean in 1883-4;—List of Works on the Geology, Mineralogy, and Palæontology of Staffordshire, Worcestershire, and Warwickshire;—On Slaty Cleavage and allied Rock-Structures, with special reference to the Mechanical Theories of their Origin;—On the Strength of Telegraph Poles;—On the Use of Index Numbers in the Investigation of Trade Statistics;—The Forth Bridge Works;—Electric Lighting at the Forth Bridge Works;—The New Tay Viaduct.

Together with the Transactions of the Sections, Sir Lyon Playfair's Address, and Recommendations of the Association and its Committees.

REPORT OF THE FIFTY-SIXTH MEETING, at Birmingham, September 1886, *Published at £1 4s.*

CONTENTS:—Report on Standards of Light;—Report of the Committee for preparing Instructions for the practical work of Tidal Observation, and Fourth Report on the Harmonic Analysis of Tidal Observations;—Report of the Committee for co-operating with the Scottish Meteorological Society in making Meteorological Observations on Ben Nevis;—Third Report on the best methods of recording the Direct Intensity of Solar Radiation;—Second Report on the best means of Comparing and Reducing Magnetic Observations;—First Report on our Experimental Knowledge of the Properties of Matter with respect to Volume, Pressure, Temperature, and Specific Heat;—Third Report of the Committee for co-operating with Mr. E. J. Lowe in his project of establishing a Meteorological Observatory near Chepstow on a permanent and scientific basis;—Report of the Committee for inviting designs for a good Differential Gravity Meter in supersession of the Pendulum;—Report of the Committee for constructing and issuing practical Standards for use in Electrical Measurements;—Second Report of the Committee for promoting Tidal Observations in Canada;—Report of the Committee for the reduction and tabulation of Tidal Observations in the English Channel, made with the Dover Tide-gauge, and for connecting them with Observations made on the French Coast;—Report of the Committee for preparing a new series of Wave-length Tables of the Spectra of the Elements;—Second Report of the Committee for investigating the subject of Vapour Pressures and Refractive Indices of Salt Solutions;—Second Report of the Committee for investigating certain Physical Constants of Solution, especially the Expansion of Saline Solutions;—Report (provisional) on the influence of the Silent Discharge of Electricity on Oxygen and other Gases;—Report on Isomeric Naphthalene Derivatives;—Report on the Exploration of the Caves of North Wales;—Fourteenth Report on the Erratic Blocks of England, Wales, and Ireland;—Report on the Volcanic Phenomena of Vesuvius and its neighbourhood;—Fourth Report on the Fossil Phyllopoda of the Palæozoic Rocks;—Twelfth Report on the Circulation of Underground Waters in the Permeable Formations of England and Wales, and the Quantity and Character of the Water supplied to various Towns and Districts from these Formations;—Second Report on the Fossil Plants of the Tertiary and Secondary Beds of the United Kingdom;—Report on the Mechanism of the Secretion of Urine;—Report of the Committee for promoting the establishment of a Marine Biological Station at Granton, Scotland;—Report on the occupation of a Table at the Zoological Station at Naples;—Report on the Migration of Birds;—Report of the Committee for continuing the Researches on Food-Fishes and Invertebrates at the St. Andrews Marine Laboratory;—Report on the Depth of the Permanently Frozen Soil in the Polar Regions, its Geographical Limits and relation to the Pole of greatest cold;—Report of the Committee for taking into consideration the Combination of the Ordnance and Admiralty Surveys, and the Production of a Bathy-hypsographical Map of the British Isles;—Report of the Committee for drawing attention to the desirability of further Research in the Antarctic Regions;—Report on the teaching of Science in Ele-

mentary Schools;—Report on the Regulation of Wages by means of Sliding Scales;—Report on the Endurance of Metals under repeated and varying Stresses, and the proper working Stresses on Railway Bridges and other structures subject to varying loads;—Report on the Prehistoric Race in the Greek Islands;—Report of the Committee for investigating and publishing reports on the physical characters, languages, and industrial and social condition of the North-western Tribes of the Dominion of Canada;—Report to the Council of the Corresponding Societies Committee;—Report on Electrolysis in its Physical and Chemical Bearings;—Sixth Report on the Volcanic Phenomena of Japan;—Second Report on the Rate of Erosion of the Sea-coasts of England and Wales, and the Influence of the Artificial Abstraction of Shingle or other Material in that action;—The Modern Development of Thomas Young's Theory of Colour-vision;—On the Explicit Form of the Complete Cubic Differential Resolvent;—On the Phenomena and Theories of Solution;—On the Exploration of the Raygill Fissure in Lothersdale, Yorkshire;—An Accurate and Rapid Method of estimating the Silica in an Igneous Rock:—On some Points for the Consideration of English Engineers with reference to the Design of Girder Bridges;—The Sphere and Roller Mechanism for Transmitting Power;—On Improvements in Electric Safety Lamps;—On the Birmingham, Tame, and Rea District Drainage.

Together with the Transactions of the Sections, Sir J. William Dawson's Address, and Recommendations of the Association and its Committees.

REPORT OF THE FIFTY-SEVENTH MEETING, at Manchester, August and September 1887, *Published at* £1 4*s*.

CONTENTS:—Third Report of the Committee for promoting Tidal Observations in Canada;—Fourth Report on the best methods of recording the direct Intensity of Solar Radiation;—Report of the Committee for co-operating with the Scottish Meteorological Society in making Meteorological Observations on Ben Nevis;—Fourth Report of the Committee for co-operating with Mr. E. J. Lowe in his project of establishing on a permanent and scientific basis a Meteorological Observatory near Chepstow;—Final Report of the Committee for co-operating with the Meteorological Society of the Mauritius in the publication of Daily Synoptic Charts of the Indian Ocean for the year 1861;—Second Report of the Committee for inviting designs for a good Differential Gravity Meter in supersession of the Pendulum;—Report on the desirability of combined action for the purpose of Translation of Foreign Memoirs;—Report on the Action of the Silent Discharge of Electricity on Oxygen and other Gases;—Report on the Influence of Silicon on the properties of Steel;—Third Report on Standards of Light;—Third Report on certain Physical Constants of Solution, especially the Expansion of Saline Solutions;—Report on the Nature of Solution;—Report on the Bibliography of Solution;—Report of the Committee for making arrangements for assisting the Marine Biological Association Laboratory at Plymouth;—Fifth Report on the Fossil Phyllopoda of the Palæozoic Rocks;—Report on the Migration of Birds;—Report on the Flora and Fauna of the Cameroons Mountain;—Report on the occupation of a Table at the Zoological Station at Naples;—Report of the Committee for aiding in the maintenance of the establishment of a Marine Biological Station at Granton, Scotland;—Report of the Committee for continuing the preparation of a Report on our present knowledge of the Flora of China;—Report on the question of accurately defining the term 'British' as applied to the Marine Fauna and Flora of our Islands;—Report of the Committee for taking steps for the establishment of a Botanical Station at Peradeniya, Ceylon;—Report on the Provincial Museums of the United Kingdom;—First Report on the Disappearance of Native Plants from their Local Habitats;—Report on the Mechanism of the Secretion of Urine;—Report on the Herds of Wild Cattle in Chartley Park and other parks in Great Britain;—Report on the Physiology of the Lymphatic System;—Report on the Depth of Permanently Frozen Soil in the Polar Regions, its Geographical Limits and relation to the present poles of greatest cold;—Report of the Committee for co-operating with the Royal Geographical Society in endeavouring to bring before the authorities of the Universities of Oxford and Cambridge the advisability of promoting the study of Geography by establishing special Chairs for the purpose;—Final Report of the Committee for considering the combination of the Ordnance and Admiralty Surveys, and the production of a Bathy-hypsographical Map of the British Islands;—Report on the teaching of Science in Elementary Schools;—Report on the Prehistoric Inhabitants of the British Islands;—Report of the Committee for editing

a new Edition of 'Anthropological Notes and Queries';—Third Report on the North-Western Tribes of the Dominion of Canada;—Second Report on the Prehistoric Race in the Greek Islands;—Report of the Committee for constructing and issuing practical Standards for use in Electrical Measurements;—Supplement to a Report on Optical Theories;—First Report on the 'Manure' Gravels of Wexford;—Seventh Report on the Volcanic Phenomena of Japan;—Report on the Volcanic Phenomena of Vesuvius and its neighbourhood;—Third Report on the Fossil Plants of the Tertiary and Secondary Beds of the United Kingdom;—Report on the Microscopical Examination of the Older Rocks of Anglesey;—Second Report on Isomeric Naphthalene Derivatives;—Report on the Carboniferous Flora of Halifax and its neighbourhood;—Fifteenth Report on the Erratic Blocks of England, Wales, and Ireland;—Report on the best methods of ascertaining and measuring Variations in the Value of the Monetary Standard;—Second Report on the Cae Gwyn Cave, North Wales;—Report on the Regulation of Wages by means of Lists in the Cotton Industry;—Third Report on the best means of comparing and reducing Magnetic Observations;—Second Report on Electrolysis in its Physical and Chemical Bearings;—Thirteenth Report on the Circulation of Underground Waters in the Permeable Formations of England and Wales, and the Quantity and Character of the Water supplied to various Towns and Districts from these Formations;—Report on the Higher Eocene Beds of the Isle of Wight;—Report on the Endurance of Metals under repeated and varying stresses, and the proper working stresses on Railway Bridges and other structures subject to varying loads;—Report of the Committee for procuring Racial Photographs from the Ancient Egyptian Pictures and Sculptures;—Report of the Corresponding Societies Committee;—On the Vortex Theory of the Luminiferous Æther;—On the Theory of Electric Endosmose and other Allied Phenomena, and on the Existence of a Sliding Coefficient for a Fluid in contact with a Solid;—Gold and Silver: their Geological Distribution and their Probable Future Production;—Recent Illustrations of the Theory of Rent, and their Effect on the Value of Land;—On certain Laws relating to the Régime of Rivers and Estuaries, and on the possibility of Experiments on a small scale;—Experiments on the Mechanical Equivalent of Heat on a large scale;—On an Electric Current Meter.

Together with the Transactions of the Sections, Sir H. E. Roscoe's Address, and Recommendations of the Association and its Committees.

REPORT OF THE FIFTY-EIGHTH MEETING, at Bath, September 1888, *Published at* £1 4*s*.

CONTENTS:—Third Report of the Committee for promoting Tidal Observations in Canada;—Report of the Committee for considering the desirability of introducing a Uniform Nomenclature for the Fundamental Units of Mechanics, and of co-operating with other bodies engaged in similar work;—Fourth Report on the best means of Comparing and Reducing Magnetic Observations;—Fourth Report on Standards of Light;—Report of the Committee for co-operating with the Scottish Meteorological Society in making Meteorological Observations on Ben Nevis;—Second Report on the Bibliography of Solution;—Report of the Committee for constructing and issuing Practical Standards for use in Electrical Measurements;—Second Report on the Influence of Silicon on the properties of Steel;—Third Report of the Committee for inviting designs for a good Differential Gravity Meter in supersession of the pendulum;—Report on the present methods of teaching Chemistry;—Report on the action of Light on the Hydracids of Halogens in presence of Oxygen;—Second Report on the Nature of Solution;—Report of the Committee for making arrangements for assisting the Marine Biological Association Laboratory at Plymouth;—Third Report on Isomeric Naphthalene Derivatives;—Third Report on the Prehistoric Race in the Greek Islands;—Report on the effects of different occupations and employments on the Physical Development of the Human Body;—Sixteenth Report on the Erratic Blocks of England, Wales, and Ireland;—Report of the Committee for preparing a further Report upon the Provincial Museums of the United Kingdom;—Second Report on the 'Manure' Gravels of Wexford;—Report of the Committee for continuing the Researches on Food-Fishes at the St. Andrews Marine Laboratory;—Fourteenth Report on the Circulation of Underground Waters in the Permeable Formations of England and Wales, and the Quantity and Character of the Water supplied to various Towns and Districts from these Formations;—Report on the Migration of Birds;—Report on the Flora of the Carboniferous Rocks of Lancashire

and West Yorkshire;—Report on the Occupation of a Table at the Zoological Station at Naples;—Report on the teaching of Science in Elementary Schools;—Sixth Report on the Fossil Phyllopoda of the Palæozoic Rocks;—Second Report on the best method of ascertaining and measuring Variations in the Value of the Monetary Standard;—Report as to the Statistical Data available for determining the amount of the Precious Metals in use as Money in the principal Countries, the chief forms in which the Money is employed, and the amount annually used in the Arts;—Fourth Report on the North-Western Tribes of the Dominion of Canada;—Report of the Corresponding Societies Committee;—Second Report on the Prehistoric Inhabitants of the British Islands;—Third Report of the Committee for drawing attention to the desirability of prosecuting further research in the Antarctic Regions;—Report of the Committee for aiding in the maintenance of the establishment of a Marine Biological Station at Granton, Scotland;—Report on the Volcanic Phenomena of Vesuvius and its neighbourhood;—Report of the Committee to arrange an investigation of the Seasonal Variations of Temperature in Lakes, Rivers, and Estuaries in various parts of the United Kingdom, in co-operation with the local societies represented on the Association;—Report on an ancient Sea-beach near Bridlington Quay;—Report on the Development of the Oviduct and connected structures in certain fresh-water Teleostei;—Third Report on Electrolysis in its Physical and Chemical Bearings;—Report on the Flora of the Bahamas;—Second Report on the Physiology of the Lymphatic System;—Report on the Microscopic Structure of the Older Rocks of Anglesey;—Report on our present knowledge of the Flora of China;—Second Report of the Committee for taking steps for the establishment of a Botanical Station at Peradeniya, Ceylon;—Eighth Report on the Earthquake and Volcanic Phenomena of Japan;—Report on the present state of our knowledge of the Zoology and Botany of the West India Islands, and the steps taken to investigate ascertained deficiencies in the Fauna and Flora;—Second Report on our Experimental Knowledge of the Properties of Matter with respect to Volume, Pressure, Temperature, and Specific Heat;—Report on the advisability and possibility of establishing in other parts of the country observations upon the prevalence of Earth Tremors similar to those now being made in Durham;—The Relations between Sliding Scales and Economic Theory;—Index-numbers as illustrating the Progressive Exports of British Produce and Manufactures;—The Friction of Metal Coils;—Sur l'application de l'analyse spectrale à la mécanique moléculaire et sur les spectres de l'oxygène.

Together with the Transactions of the Sections, Sir F. J. Bramwell's Address, and **Recommendations of the Association and its Committees.**

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FOR

THE ADVANCEMENT OF SCIENCE.

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Prof. Huxley, LL.D., F.R.S.
Prof. Sir Wm. Thomson, LL.D.
Prof. Williamson, Ph.D., F.R.S.
Prof. Tyndall, D.C.L., F.R.S.
Sir John Hawkshaw, F.R.S.
Prof. Allman, M.D., F.R.S.
Sir A. C. Ramsay, LL.D., F.R.S.
Sir John Lubbock, Bart., F.R.S.
Prof. Cayley, LL.D., F.R.S.
Lord Rayleigh, D.C.L., Sec.R.S.
Sir Lyon Playfair, K.C.B.
Sir Wm. Dawson, C.M.G., F.R.S.
Sir H. E. Roscoe, D.C.L., F.R.S.
Sir F. J. Bramwell, Bart., F.R.S.

GENERAL OFFICERS OF FORMER YEARS.

F. Galton, Esq., F.R.S.
Dr. T. A. Hirst, F.R.S.
Prof. Michael Foster, Sec.R.S.
George Griffith, Esq., M.A., F.C.S.
P. L. Sclater, Esq., Ph.D., F.R.S.
Prof. Bonney, D.Sc., F.R.S.

AUDITORS.

Dr. W. H. Perkin, F.R.S.
Dr. J. H. Gladstone, F.R.S.
W. T. Thiselton-Dyer, Esq., F.R.S.

LIST OF MEMBERS

OF THE

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

1890

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* indicates Life Members entitled to the Annual Report.
§ indicates Annual Subscribers entitled to the Annual Report.
‡ indicates Subscribers not entitled to the Annual Report.
Names without any mark before them are Life Members not entitled to the Annual Report.
Names of Members of the GENERAL COMMITTEE are printed in SMALL CAPITALS.
Names of Members whose addresses are incomplete or not known are in *italics*.

Notice of changes of residence should be sent to the Secretary, 22 Albemarle Street, London, W.

Year of Election.

1887. *Abbe, Cleveland. Weather Bureau, Army Signal Office, Washington, U.S.A.
1881. *Abbott, R. T. G. Quarry Cottage, Norton, Malton.
1887. ‡Abbott, T. C. Eastleigh, Queen's-road, Bowdon, Cheshire.
1863. *ABEL, Sir FREDERICK AUGUSTUS, C.B., D.C.L., D.Sc., F.R.S., V.P.C.S., President of the Government Committee on Explosives. (PRESIDENT ELECT.) 1 Adam-street, Adelphi, London, W.C.
1856. ‡*Abercrombie, John, M.D. 39 Welbeck-street, London, W.*
1886. §ABERCROMBY, The Hon. RALPH, F.R.Met.Soc. 21 Chapel-street, Belgrave-square, London, S.W.
1885. *ABERDEEN, The Right Hon. the Earl of, LL.D. 37 Grosvenor-square, London, W.
1885. ‡Aberdeen, The Countess of. 37 Grosvenor-square, London, W.
1885. ‡Abernethy, David W. Ferryhill Cottage, Aberdeen.
1863. *ABERNETHY, JAMES, M.Inst.C.E., F.R.S.E. 4 Delahay-street, Westminster, S.W.
1885. ‡Abernethy, James W. 2 Rubislaw-place, Aberdeen.
1873. *ABNEY, Captain W. DE W., R.E., C.B., D.C.L., F.R.S., F.R.A.S., F.C.S. Willeslie House, Wetherby-road, South Kensington, London, S.W.

Year of Election.

1886. §Abraham, Harry. 147 High-street, Southampton.
1877. ‡Ace, Rev. Daniel, D.D., F.R.A.S. Laughton, near Gainsborough, Lincolnshire.
1884. ‡Acheson, George. Collegiate Institute, Toronto, Canada.
1873. ‡Ackroyd, Samuel. Greaves-street, Little Horton, Bradford, Yorkshire.
1882. *Acland, Alfred Dyke. Oxford.
1869. ‡Acland, Charles T. D., M.P. Sprydoncote, Exeter.
1877. *Acland, Captain Francis E. Dyke, R.A. School of Gunnery, Shoeburyness.
1873. *Acland, Rev. H. D., M.A. Nymet St. George, South Molton, Devon.
1873. *ACLAND, Sir HENRY W. D., K.C.B., M.A., M.D., LL.D., F.R.S., F.R.G.S., Radcliffe Librarian and Regius Professor of Medicine in the University of Oxford. Broad-street, Oxford.
1877. *Acland, Theodore Dyke, M.A. 7 Brook-street, London, W.
1860. ‡ACLAND, Sir THOMAS DYKE, Bart., M.A., D.C.L., M.P. Sprydoncote, Exeter; and Athenæum Club, London, S.W.
1887. ‡ADAMI, J. G., B.A. New Museums, Cambridge.
1884. ‡Adams, Frank Donovan. Geological Survey, Ottawa, Canada.
1876. ‡Adams, James. 9 Royal-crescent West, Glasgow.
*ADAMS, JOHN COUCH, M.A., LL.D., D.Sc., F.R.S., F.R.A.S., Director of the Observatory and Lowndean Professor of Astronomy and Geometry in the University of Cambridge. The Observatory, Cambridge.
1871. §Adams, John R. 37 De Vere-gardens, Kensington, London, S.W.
1879. *ADAMS, Rev. THOMAS, M.A., Principal of Bishop's College, Lennoxville, Canada.
1877. ‡ADAMS, WILLIAM. 3 Sussex-terrace, Plymouth.
1869. *ADAMS, WILLIAM GRYLLS, M.A., D.Sc., F.R.S., F.G.S., F.C.P.S., Professor of Natural Philosophy and Astronomy in King's College, London. 43 Notting Hill-square, London, W.
1879. ‡Adamson, Robert, M.A., LL.D., Professor of Logic and Political Economy in Owens College, Manchester. 1 Derby-road, Fallowfield, Manchester.
1887. §Adamson, Samuel A., F.G.S. 52 Wellclose-terrace, Leeds.
1865. *Adkins, Henry. Northfield, near Birmingham.
1883. §Adshead, Samuel. School of Science, Macclesfield.
1884. ‡Agnew, Cornelius R. 266 Maddison-avenue, New York, U.S.A.
1887. ‡Agnew, William. Summer Hill, Pendleton, Manchester.
1884. ‡Aikins, Dr. W. T. Jarvis-street, Toronto, Canada.
1864. *Ainsworth, David. The Flosh, Cleator, Carnforth.
1871. *Ainsworth, John Stirling. Harecroft, Cumberland.
1871. ‡Ainsworth, William M. The Flosh, Cleator, Carnforth.
AIRY, Sir GEORGE BIDDELL, K.C.B., M.A., LL.D., D.C.L., F.R.S., F.R.A.S. The White House, Croom's Hill, Greenwich, S.E.
1871. §Aitken, John, F.R.S., F.R.S.E. Darroch, Falkirk, N.B.
Aitken, Thomas. Ashfield, Fallowfield, Manchester.
Akroyd, Edward. Bankfield, Halifax.
1884. *Alabaster, H. 22 Paternoster-row, London, E.C.
1886. *Albright, G. S. The Elms, Edgbaston, Birmingham.
1862. ‡ALCOCK, Sir RUTHERFORD, K.C.B., D.C.L., F.R.G.S. The Athenæum Club, Pall Mall, London, S.W.
1861. *Alcock, Thomas, M.D. Oakfield, Sale, Manchester.
*Aldam, William. Frickley Hall, near Doncaster.
1887. ‡Alexander, B. Fernlea, Fallowfield, Manchester.
1883. ‡Alexander, George. Kildare-street Club, Dublin.
1888. *Alexander, Patrick Y. 8 Portland-place, Bath.

Year of Election.

1873. ‡Alexander, Reginald, M.D. 13 Hallfield-road, Bradford, Yorkshire.
1858. ‡ALEXANDER, WILLIAM, M.D. Halifax.
1883. ‡Alger, Miss Ethel. The Manor House, Stoke Damerel, South Devon.
1883. ‡Alger, W. H. The Manor House, Stoke Damerel, South Devon.
1883. ‡Alger, Mrs. W. H. The Manor House, Stoke Damerel, South Devon.
1867. ‡Alison, George L. C. Dundee.
1859. ‡Allan, Alexander. Scottish Central Railway, Perth.
1885. ‡Allan, David. West Cults, near Aberdeen.
1871. ‡Allan, G., M.Inst.C.E. 10 Austin Friars, London, E.C.
1871. ‡ALLEN, ALFRED H., F.C.S. 67 Surrey-street, Sheffield.
1887. *Allen, Arthur Ackland. Overbrook, Kersal, Manchester.
1879. *Allen, Rev. A. J. C. The College, Chester.
1887. *Allen, Charles Peter. Overbrook, Kersal, Manchester.
1888. ‡Allen, F. J. Mason College, Birmingham.
1884. ‡Allen, Rev. George. Shaw Vicarage, Oldham.
1887. §Allen, John. Kilgrimol School, St. Anne's-on-the-Sea, viâ Preston.
1878. ‡Allen, John Romilly. 5 Albert-terrace, Regent's Park, London, N.W.
1861. ‡Allen, Richard. Didsbury, near Manchester.
1887. *Allen, Russell. 2 Parkwood, Victoria Park, Manchester.
1889. §Allhusen, Alfred. Low Fell, Gateshead.
1863. ‡Allhusen, C. Elswick Hall, Newcastle-on-Tyne.
1889. §Allhusen, Frank. Low Fell, Gateshead.
*ALLMAN, GEORGE J., M.D., LL.D., F.R.S. L. & E., M.R.I.A., F.L.S., Emeritus Professor of Natural History in the University of Edinburgh. Ardmore, Parkstone, Dorset.
1887. *Allnutt, J. W. F., M.A. 12 Chapel-row, Portsea, Hants.
1886. ‡Allport, Samuel. 50 Whitall-street, Birmingham.
1887. ‡Alward, G. L. 11 Hamilton-street, Grimsby, Yorkshire.
1873. ‡Ambler, John. North Park-road, Bradford, Yorkshire.
1883. §Amery, John Sparke. Druid House, Ashburton, Devon.
1883. §Amery, Peter Fabyan Sparke. Druid House, Ashburton, Devon.
1884. ‡Ami, Henry. Geological Survey, Ottawa, Canada.
1876. ‡*Anderson, Alexander. 1 St. James's-place, Hillhead, Glasgow.*
1878. ‡*Anderson, Beresford. Saint Ville, Killiney.*
1885. ‡Anderson, Charles Clinton. 4 Knaresborough-place, Cromwell-road, London, S.W.
1850. ‡Anderson, Charles William. Belvedere, Harrogate.
1883. ‡Anderson, Miss Constance. 17 Stonegate, York.
1885. *Anderson, Hugh Kerr. Frognal Park, Hampstead, London, N.W.
1874. ‡Anderson, John, J.P., F.G.S. Holywood, Belfast.
1859. ‡ANDERSON, PATRICK. 15 King-street, Dundee.
1888. *Anderson, R. Bruce. 39 Kempshott-road, Streatham, London, S.W.
1889. §Anderson, Robert Simpson. Elswick Collieries, Newcastle-upon-Tyne.
1887. §Anderson, Professor R. J., M.D. Queen's College, Galway.
1880. *ANDERSON, TEMPEST, M.D., B.Sc. 17 Stonegate, York.
1886. *ANDERSON, WILLIAM, D.C.L., M.Inst.C.E. Lesney House, Erith, Kent.
1880. ‡Andrew, Mrs. 126 Jamaica-street, Stepney, London, E.
1883. ‡Andrew, Thomas, F.G.S. 18 Southernhay, Exeter.
1880. *Andrews, Thornton, M.Inst.C.E. Cefn Eithen, Swansea.
1886. §Andrews, William. Gosford Lodge, Coventry.
1883. §Anelay, Miss M. Mabel. Girton College, Cambridge.
1877. §ANGELL, JOHN, F.C.S. 81 Ducie-grove, Oxford-street, Manchester.
1886. §Annan, John. Wolverhampton.
1886. ‡Ansell, Joseph. 38 Waterloo-street, Birmingham.

Year of Election.

1878. ‡Anson, Frederick H. 15 Dean's-yard, Westminster, S.W.
Anthony, John, M.D. 6 Greenfield-crescent, Edgbaston, Birmingham.
1886. §Arblaster, Edmund, M.A. The Grammar School, Carlisle.
1870. ‡Archer, Francis. 14 Cook-street, Liverpool.
1874. ‡Archer, William, F.R.S., M.R.I.A. 11 South Frederick-street, Dublin.
1884. *Archibald, E. Douglas. Grosvenor House, Tunbridge Wells.
1851. ‡Argyll, His Grace the Duke of, K.G., K.T., D.C.L., F.R.S. L. & E., F.G.S. Argyll Lodge, Kensington, London, W.; and Inverary, Argyllshire.
1884. §Arlidge, John Thomas, M.D., B.A. The High Grove, Stoke-upon-Trent.
1883. §Armistead, Richard. 28 Chambres-road, Southport.
1883. *Armistead, William. 15 Rupert-street, Compton-road, Wolverhampton.
1887. ‡Armitage, Benjamin. Chomlea, Pendleton, Manchester.
1861. ‡Armitage, William. 95 Portland-street, Manchester.
1867. *Armitstead, George. Errol Park, Errol, N.B.
1857. *Armstrong, The Right Hon. Lord, C.B., LL.D., D.C.L., F.R.S. Jesmond Dene, Newcastle-upon-Tyne.
1879. *Armstrong, Sir Alexander, K.C.B., M.D., LL.D., F.R.S., F.R.G.S. The Albany, London, W.
1886. ‡Armstrong, George Frederick, M.A., F.R.S.E., F.G.S., Regius Professor of Engineering in the University of Edinburgh. The University, Edinburgh.
1873. §Armstrong, Henry E., Ph.D., F.R.S., Sec.C.S., Professor of Chemistry in the City and Guilds of London Institute, Central Institution, Exhibition-road, London, S.W. 55 Granville Park, Lewisham, S.E.
1876. ‡Armstrong, James. Bay Ridge, Long Island, New York, U.S.A.
1889. §Armstrong, John A. 32 Eldon-street, Newcastle-upon-Tyne.
1884. ‡Armstrong, Robert B. Junior Carlton Club, Pall Mall, London, S.W.
Armstrong, Thomas. Higher Broughton, Manchester.
1889. §Armstrong, Thomas John. 14 Hawthorn-terrace, Newcastle-upon-Tyne.
1870. ‡Arnott, Thomas Reid. Bramshill, Harlesden Green, London, N.W.
1853. *Arthur, Rev. William, M.A. Clapham Common, London, S.W.
1886. ‡Ascough, Jesse. Patent Borax Company, Newmarket-street, Birmingham.
1870. *Ash, Dr. T. Linnington. Holsworthy, North Devon.
1874. ‡Ashe, Isaac, M.B. Dundrum, Co. Dublin.
1889. §Ashley, Howard M. Ferrybridge, Normanton.
1873. ‡Ashton, John. Gorse Bank House, Windsor-road, Oldham.
Ashton, Thomas, J.P. Ford Bank, Didsbury, Manchester.
1887. ‡Ashton, Thomas Gair, M.A. 36 Charlotte-street, Manchester.
1866. ‡Ashwell, Henry. Woodthorpe, Nottingham.
*Ashworth, Edmund. Egerton Hall, Bolton-le-Moors.
1887. ‡Ashworth, Mrs. Harriet. Thorne Bank, Heaton Moor, near Stockport.
Ashworth, Henry. Turton, near Bolton.
1888. §Ashworth, J. J. 35 Mosley-street, Manchester.
1887. §Ashworth, John Wallwork. Thorne Bank, Heaton Moor, near Stockport.
1887. ‡Aspland, Arthur P. Werneth Lodge, Gee Cross, near Manchester.

Year of Election.

1875. *Aspland, W. Gaskell. Care of Manager, Union Bank, Chancery-lane, London, W.C.
1861. §Asquith, J. R. Infirmary-street, Leeds.
1861. ‡Aston, Theodore. 11 New-square, Lincoln's Inn, London, W.C.
1872. *ATCHISON, ARTHUR T., M.A. (SECRETARY.) 22 Albemarle-street, London, W.
1887. §Atkinson, Rev. C. Chetwynd, B.A. Goresfield, Ashton-on-Mersey.
1865. *ATKINSON, EDMUND, Ph.D., F.C.S. Portesbery Hill, Camberley, Surrey.
1884. ‡Atkinson, Edward. Brookline, Massachusetts, Boston, U.S.A.
1863. *Atkinson, G. Clayton. 21 Windsor-terrace, Newcastle-on-Tyne.
1861. ‡Atkinson, Rev. J. A. Longsight Rectory, near Manchester.
1858. *Atkinson, John Hastings. 12 East Parade, Leeds.
1881. ‡Atkinson, J. T. The Quay, Selby, Yorkshire.
1881. ‡Atkinson, Robert William. 44 Loudoun-square, Cardiff.
1863. *ATTFIELD, Professor J., M.A., Ph.D., F.R.S., F.C.S. 17 Bloomsbury-square, London, W.C.
1884. ‡Auchincloss, W. S. 209 Church-street, Philadelphia, U.S.A.
1886. ‡Aulton, A. D., M.D. Walsall.
1860. *Austin-Gourlay, Rev. William E. C., M.A. The Rectory, Stanton St. John, near Oxford.
1865. *Avery, Thomas. Church-road, Edgbaston, Birmingham.
1881. ‡AXON, W. E. A. Fern Bank, Higher Broughton, Manchester.
1888. ‡Ayre, Rev. J. W., M.A. 30 Green-street, Grosvenor-square, London, W.
1877. *AYRTON, W. E., F.R.S., Professor of Applied Physics in the City and Guilds of London Institute, Central Institution, Exhibition-road, London, S.W.

*BABINGTON, CHARLES CARDALE, M.A., F.R.S., F.L.S., F.G.S., Professor of Botany in the University of Cambridge. 5 Brookside, Cambridge.
1884. ‡Baby, The Hon. G. Montreal, Canada.
Backhouse, Edmund. Darlington.
1863. ‡Backhouse, T. W. West Hendon House, Sunderland.
1883. *Backhouse, W. A. St. John's Wolsingham, near Darlington.
1887. *Bacon, Thomas Walter. 4 Lyndhurst-road, Hampstead, London, N.W.
1887. ‡Baddeley, John. 1 Charlotte-street, Manchester.
1881. ‡Baden-Powell, Sir George S., K.C.M.G., M.A., M.P., F.R.A.S., F.S.S. 8 St. George's-place, Hyde Park, London, S.W.
1877. ‡Badock, W. F. Badminton House, Clifton Park, Bristol.
1883. ‡Bagrual, P. H. St. Stephen's Club, Westminster, S.W.
1883. ‡Baildon, Dr. 65 Manchester-road, Southport.
1883. *Bailey, Charles, F.L.S. Ashfield, College-road, Whalley Range, Manchester.
1870. ‡Bailey, Dr. Francis J. 51 Grove-street, Liverpool.
1887. *Bailey, G. H., D.Sc., Ph.D. Owens College, Manchester.
1878. ‡Bailey, John. The Laurels, Wittington, near Hereford.
1865. ‡*Bailey, Samuel, F.G.S. The Peck, Walsall.*
1855. ‡Bailey, William. Horseley Fields Chemical Works, Wolverhampton.
1887. ‡Bailey, W. H. Summerfield, Eccles Old-road, Manchester.
1866. ‡Baillon, Andrew. British Consulate, Brest.
1878. ‡Baily, Walter. 176 Haverstock-hill, London, N.W.
1885. ‡BAIN, ALEXANDER, M.A., LL.D., Rector of the University of Aberdeen. Ferryhill Lodge, Aberdeen.

Year of Election.

1873. ‡Bain, Sir James. 3 Park-terrace, Glasgow.
1885. ‡Bain, William N. Collingwood, Pollokshields, Glasgow.
*Baines, Sir Edward, J.P. St. Ann's Hill, Burley, Leeds.
1858. ‡Baines, T. Blackburn. 'Mercury' Office, Leeds.
1882. *Baker, Benjamin, M.Inst.C.E. 2 Queen Square-place, Westminster, S.W.
1866. ‡Baker, Francis B. Sherwood-street, Nottingham.
1886. ‡Baker, Harry. 262 Plymouth-grove, Manchester.
1861. *Baker, John. The Gables, Buxton.
1881. ‡Baker, Robert, M.D. The Retreat, York.
1863. ‡Baker, William. 6 Taptonville, Sheffield.
1875. *Baker, W. Mills. The Holmes, Stoke Bishop, Bristol.
1875. ‡Baker, W. Proctor. Brislington, Bristol.
1881. ‡Baldwin, Rev. G. W. de Courcy, M.A. Lord Mayor's Walk, York.
1884. ‡Balete, Professor E. Polytechnic School, Montreal, Canada.
1871. ‡Balfour, G. W. Whittinghame, Prestonkirk, Scotland.
1875. ‡Balfour, Isaac Bayley, D.Sc., M.D., F.R.S.L. & E., Professor of Botany in the University of Edinburgh. Inverleith House, Edinburgh.
1883. ‡Balfour, Mrs. I. Bayley. Inverleith House, Edinburgh.
1878. *Ball, Charles Bent, M.D. 16 Lower Fitzwilliam-street, Dublin.
1866. *Ball, Sir Robert Stawell, M.A., LL.D., F.R.S., F.R.A.S., Andrews Professor of Astronomy in the University of Dublin, and Astronomer Royal for Ireland. The Observatory, Dunsink, Co. Dublin.
1878. ‡Ball, Valentine, M.A., F.R.S., F.G.S., Director of the Museum of Science and Art, Dublin.
1883. *Ball, W. W. Rouse, M.A. Trinity College, Cambridge.
1886. §Ballantyne, J. W., M.B. 50 Queen-street, Edinburgh.
1884. ‡Ballon, Dr. Naham. Sandwich, Illinois, U.S.A.
1869. ‡Bamber, Henry K., F.C.S. 5 Westminster-chambers, Victoria-street, Westminster, S.W.
1882. ‡Bance, Major Edward. Limewood, The Avenue, Southampton.
1852. ‡Bangor, Viscount. Castleward, Co. Down, Ireland.
1870. ‡Banister, Rev. William, B.A. St. James's Mount, Liverpool.
1884. ‡Bannatyne, Hon. A. G. Winnipeg, Canada.
1884. ‡Barbeau, E. J. Montreal, Canada.
1866. ‡Barber, John. Long-row, Nottingham.
1884. ‡Barber, Rev. S. F. West Raynham Rectory, Swaffham, Norfolk.
1861. *Barbour, George. Bolesworth Castle, Tattenhall, Chester.
1859. ‡*Barbour, George F.* 11, *George-square, Edinburgh.*
1855. ‡Barclay, Andrew. Kilmarnock, Scotland.
1871. ‡Barclay, George. 17 Coates-crescent, Edinburgh.
1852. *Barclay, J. Gurney. 54 Lombard-street, London, E.C.
1860. *Barclay, Robert. High Leigh, Hoddesden, Herts.
1876. *Barclay, Robert. 21 Park-terrace, Glasgow.
1887. *Barclay, Robert. Springfield, Kersal, Manchester.
1886. ‡Barclay, Thomas. 17 Bull-street, Birmingham.
1868. *Barclay, W. L. 54 Lombard-street, London, E.C.
1881. ‡Barfoot, William, J.P. Whelford-place, Leicester.
1882. ‡Barford, J. D. Above Bar, Southampton.
1863. *Barford, James Gale, F.C.S. Wellington College, Wokingham, Berkshire.
1886. ‡Barham, F. F. Bank of England, Birmingham.
1860. *Barker, Rev. Arthur Alcock, B.D. East Bridgford Rectory, Nottingham.

Year of Election.

1879. ‡Barker, Elliott. 2 High-street, Sheffield.
1882. *Barker, Miss J. M. Hexham House, Hexham.
1879. *Barker, Rev. Philip C., M.A., LL.B. Ruishton Vicarage, Taunton.
1865. ‡Barker, Stephen. 30 Frederick-street, Edgbaston, Birmingham.
1870. ‡BARKLY, Sir HENRY, G.C.M.G., K.C.B., F.R.S., F.R.G.S. 1 Bina-gardens, South Kensington, London, S.W.
1889. §Barkus, Dr. B 3 Jesmond-terrace, Newcastle-upon-Tyne.
1886. ‡Barling, Gilbert. 85 Edmund-street, Edgbaston, Birmingham.
1873. ‡Barlow, Crawford, B.A. 2 Old Palace-yard, Westminster, S.W.
1889. §Barlow, H. W. L. Holly Bank, Croftsbank-road, Urmston, near Manchester.
1883. ‡Barlow, J. J. 37 Park-street, Southport.
1878. ‡Barlow, John, M.D., Professor of Physiology in Anderson's College, Glasgow.
1883. ‡Barlow, John R. Greenthorne, near Bolton.
Barlow, Lieut.-Col. Maurice (14th Regt. of Foot). 5 Great George-street, Dublin.
1885. ‡Barlow, William. Hillfield, Muswell Hill, London, N.
1873. ‡BARLOW, WILLIAM HENRY, F.R.S., M.Inst.C.E. 2 Old Palace-yard, Westminster, S.W.
1861. *Barnard, Major R. Cary, F.L.S. Bartlow, Leckhampton, Cheltenham.
1881. ‡Barnard, William, LL.B. Harlow, Essex.
1889. §Barnes, J. W. Bank, Durham.
1868. §Barnes, Richard H. Heatherlands, Parkstone, Dorset.
1884. ‡Barnett, J. D. Port Hope, Ontario, Canada.
1886. ‡Barnsley, Charles H. 32 Duchess-road, Edgbaston, Birmingham.
1881. ‡Barr, Archibald, B.Sc.
1859. ‡Barr, Lieut.-General. Apsleytoun, East Grinstead, Sussex.
1883. ‡Barrett, John Chalk. Errismore, Birkdale, Southport.
1883. ‡Barrett, Mrs. J. C. Errismore, Birkdale, Southport.
1860. ‡Barrett, T. B. 20 Victoria-terrace, Welshpool, Montgomery.
1872. *BARRETT, W. F., F.R.S.E., M.R.I.A., Professor of Physics in the Royal College of Science, Dublin.
1883. ‡Barrett, William Scott. Winton Lodge, Crosby, near Liverpool.
1887. §Barrington, Miss Amy. Fassaroe, Bray, Co. Wicklow.
1874. *BARRINGTON, R. M., M.A., LL.B., F.L.S. Fassaroe, Bray, Co. Wicklow.
1874. *Barrington-Ward, Mark J., M.A., F.L.S., F.R.G.S., H.M. Inspector of Schools. Thorneloe Lodge, Worcester.
1885. *Barron, Frederick Cadogan, M.Inst.C.E. Nervion, Beckenham-grove, Shortlands, Kent.
1881. §BARRON, G. B., M.D. Summerseat, Southport.
1866. ‡Barron, William. Elvaston Nurseries, Borrowash, Derby.
1886. ‡Barrow, George William. Baldraud, Lancaster.
1887. §Barrow, John. Beechfield, Folly-lane, Swinton, Manchester.
1886. ‡Barrow, Richard Bradbury. Lawn House, 13 Ompton-road, Edgbaston, Birmingham.
1886. ‡Barrows, Joseph. The Poplars, Yardley, near Birmingham.
1886. ‡Barrows, Joseph, jun. Ferndale, Harborne-road, Edgbaston, Birmingham.
1862. *BARRY, CHARLES. 15 Pembridge-square, London, W.
1883. ‡Barry, Charles E. 15 Pembridge-square, London, W.
1875. ‡Barry, John Wolfe. 23 Delahay-street, Westminster, S.W.
1881. ‡Barry, J. W. Duncombe-place, York.
1884. *Barstow, Miss Frances. Garrow Hill, near York.
1858. *Bartholomew, Charles. Castle Hill House, Ealing, Middlesex, W.

Year of Election.

1858. *Bartholomew, William Hamond. Ridgeway House, Cumberland-road, Headingley, Leeds.
1884. ‡Bartlett, James Herbert. 148 Mansfield-street, Montreal, Canada.
1873. ‡Bartley, George C. T., M.P. St. Margaret's House, Victoria-street, London, S.W.
1884. ‡Barton, H. M. Foster-place, Dublin.
1852. ‡Barton, James. Farndreg, Dundalk.
1887. ‡Bartrum, John S. 13 Gay-street, Bath.
*Bashforth, Rev. Francis, B.D. Minting Vicarage, near Horncastle.
1882. *Basing, The Right Hon. Lord, F.R.S. 74 St. George's-square, London, S.W.
1876. ‡Bassano, Alexander. 12 Montagu-place, London, W.
1876. ‡Bassano, Clement. Jesus College, Cambridge.
1888. *Bassett, A. B., M.A., F.R.S. Chapel Place Mansions, 322 Oxford-street, London, W.
1866. *Bassett, Henry. 26 Belitha-villas, Barnsbury, London, N.
1889. §Bastable, Professor C. F., M.A., F.S.S. 74 Kenilworth-square, Rathgar, Co. Dublin.
1869. ‡Bastard, S. S. Summerland-place, Exeter.
1871. ‡Bastian, H. Charlton, M.A., M.D., F.R.S., F.L.S., Professor of the Principles and Practice of Medicine in University College, London. 8a Manchester-square, London, W.
1889. §Batalha-Reis, J. Portuguese Consulate, Newcastle-upon-Tyne.
1883. ‡Bateman, A. E. Board of Trade, London, S.W.
1873. *Bateman, Daniel. Wissahickon, Philadelphia, U.S.A.
1868. ‡Bateman, Frederick, M.D. Upper St. Giles's-street, Norwich.
Bateman, James, M.A., F.R.S., F.R.G.S., F.L.S. Home House, Worthing.
1889. §Bates, C. J. Heddon, Wylam, Northumberland.
1864. ‡Bates, Henry Walter, F.R.S., F.L.S., Assist.-Sec. R.G.S. 1 Savile-row, London, W.
1852. ‡Bateson, Sir Robert, Bart. Belvoir Park, Belfast.
1884. ‡Bateson, William, B.A. St. John's College, Cambridge.
1851. ‡Bath and Wells, The Right Rev. Lord Arthur Hervey, Lord Bishop of, D.D. The Palace, Wells, Somerset.
1881. *Bather, Francis Arthur, M.A., F.G.S. 207 Harrow-road, London, W.
1836. ‡Batten, Edmund Chisholm. 25 Thurloe-square, London, S.W.
1863. §Bauerman, H., F.G.S. 41 Acre-lane, Brixton, London, S.W.
1867. ‡Baxter, Edward. Hazel Hall, Dundee.
1867. ‡Baxter, The Right Hon. William Edward, M.P. Ashcliffe, Dundee.
1868. ‡*Bayes, William, M.D.* 58 *Brook-street, London, W.*
Bayly, John. Seven Trees, Plymouth.
1875. *Bayly, Robert. Torr-grove, near Plymouth.
1876. *Baynes, Robert E., M.A. Christ Church, Oxford.
1887. *Baynes, Mrs. R. E. 3 Church-walk, Oxford.
1887. ‡Baynton, Alfred. 28 Gilda Brook Park, Eccles, Manchester.
1883. *Bazley, Gardner. Hatherop Castle, Fairford, Gloucestershire.
Bazley, Sir Thomas Sebastian, Bart., M.A. Hatherop Castle, Fairford, Gloucestershire.
1886. ‡Beale, C. Calle Progress No. 83, Rosario de Santa Fé, Argentine Republic.
1886. ‡Beale, Charles G. Maple Bank, Edgbaston, Birmingham.
1860. *Beale, Lionel S., M.B., F.R.S., Professor of the Principles and Practice of Medicine in King's College, London. 61 Grosvenor-street, London, W.
1882. §Beamish, Major A. W., R.E. 28 Grosvenor-road, London, S.W.

Year of Election.

1884. ‡Beamish, G. H. M. Prison, Liverpool.
1872. ‡Beanes, Edward, F.C.S. Moatlands, Paddock Wood, Brenchley, Kent.
1883. ‡Beard, Mrs. 13 South-hill-road, Toxteth Park, Liverpool.
1889. §Beare, Professor T. Hudson, F.R.S.E. University College, London, W.C.
1887. ‡Beaton, John, M.A. 219 Upper Brook-street, Chorlton-on-Medlock, Manchester.
1842. *Beatson, William. Ash Mount, Rotherham.
1888. §Beatson, W. B., M.D. 11 Cavendish-place, Bath.
1889. §Beattie, John. 5 Summerhill-grove, Newcastle-upon-Tyne.
1855. *Beaufort, W. Morris, F.R.A.S., F.R.G.S., F.R.M.S., F.S.S. 18 Piccadilly, London, W.
1886. ‡Beaugrand, M. H. Montreal.
1861. *Beaumont, Rev. Thomas George. Oakley Lodge, Leamington.
1887. *Beaumont, W. J. 10 Burlington-street, Bath.
1885. §Beaumont, W. W. Melford, Palace-road, Tulse Hill, London, S.W.
1871. *Beazley, Lieut.-Colonel George G. 74 Redcliffe-square, London, S.W.
1859. *Beck, Joseph, F.R.A.S. 68 Cornhill, London, E.C.
1864. §Becker, Miss Lydia E. 155 Shrewsbury-street, Whalley Range, Manchester.
1887. *Beckett, John Hampden. Wilmslow Park, Wilmslow, Manchester.
1860. ‡Beckles, Samuel H., F.R.S., F.G.S. 9 Grand-parade, St. Leonard's-on-Sea.
1885. §Beddard, Frank E., M.A., F.Z.S., Prosector to the Zoological Society of London. Society's Gardens, Regent's Park, London, N.W.
1866. ‡Beddard, James. Derby-road, Nottingham.
1870. §Beddoe, John, M.D., F.R.S. Clifton, Bristol.
1858. §Bedford, James. Woodhouse Cliff, near Leeds.
1878. ‡Bedson, P. Phillips, D.Sc., F.C.S., Professor of Chemistry in the College of Physical Science, Newcastle-on-Tyne.
1884. ‡Beers, W. G., M.D. 34 Beaver Hall-terrace, Montreal, Canada.
1873. ‡Behrens, Jacob. Springfield House, North-parade, Bradford, Yorkshire.
1874. ‡Belcher, Richard Boswell. Blockley, Worcestershire.
1873. ‡Bell, Asahel P. 32 St. Anne's-street, Manchester.
1871. §Bell, Charles B. 6 Spring-bank, Hull.
1884. ‡Bell, Charles Napier. Winnipeg, Canada.
Bell, Frederick John. Woodlands, near Maldon, Essex.
1860. ‡Bell, Rev. George Charles, M.A. Marlborough College, Wilts.
1880. §Bell, Henry Oswin. 13 Northumberland-terrace, Tynemouth.
1862. *Bell, Sir Isaac Lowthian, Bart., F.R.S., F.C.S., M.Inst.C.E. Rounton Grange, Northallerton.
1875. ‡Bell, James, C.B., D.Sc., Ph.D., F.R.S., F.C.S. The Laboratory, Somerset House, London, W.C.
1871. *Bell, J. Carter, F.C.S. Bankfield, The Cliff, Higher Broughton, Manchester.
1883. *Bell, John Henry. Dalton Lees, Huddersfield.
1853. ‡Bell, John Pearson, M.D. Waverley House, Hull.
1864. ‡Bell, R. Queen's College, Kingston, Canada.
1876. ‡Bell, R. Bruce, M.Inst.C.E. 203 St. Vincent-street, Glasgow.
1863. *Bell, Thomas. Oakwood, Epping.
1867. ‡Bell, Thomas. Belmont, Dundee.
1888. *Bell, Walter George, M.A. Trinity Hall, Cambridge.
1842. Bellhouse, Edward Taylor. Eagle Foundry, Manchester.

Year of Election.

Bellingham, Sir Alan. Castle Bellingham, Ireland.
1882. ‡Bellingham, William. 15 Killieser-avenue, Telford Park, Streatham Hill, London, S.W.
1884. ‡Bemrose, Joseph. 15 Plateau-street, Montreal, Canada.
1886. §Benger, Frederick Baden, F.I.C., F.C.S. 7 Exchange-street, Manchester.
1885. §Benham, William Blaxland, D.Sc. University College, London, W.C.
1870. ‡Bennett, Alfred W., M.A., B.Sc., F.L.S. 6 Park Village East, Regent's Park, London, N.W.
1836. §Bennett, Henry. Bedminster, Bristol.
1887. ‡Bennett, James M. St. Mungo Chemical Company, Ruckhill, Glasgow.
1881. §Bennett, John R. 16 West Park, Clifton, Bristol.
1883. *Bennett, Laurence Henry. Bedminster, Bristol.
1881. ‡Bennett, Rev. S. H., M.A. St. Mary's Vicarage, Bishopshill Junior, York.
1870. *Bennett, William. Oak Hill Park, Old Swan, near Liverpool.
1887. ‡Bennion, James A., M.A. 1 St. James'-square, Manchester.
1852. *Bennoch, Francis, F.S.A. 5 Tavistock-square, London, W.C.
1889. §Benson, John G. 12 Grey-street, Newcastle-upon-Tyne.
1848. ‡Benson, Starling. Gloucester-place, Swansea.
1863. ‡Benson, William. Fourstones Court, Newcastle-on-Tyne.
1885. *Bent, J. Theodore. 13 Great Cumberland-place, London, W.
1884. ‡Bentham, William. 724 Sherbrooke-street, Montreal, Canada
1863. ‡Bentley, Robert, F.L.S., Professor of Botany in King's College, London. 38 Penywern-road, Earl's Court, London, S.W.
1886. ‡*Benton, William Elijah. Littleworth House, Hednesford, Staffordshire.*
1876. ‡Bergius, Walter C. 9 Loudon-terrace, Hillhead, Glasgow.
1863. ‡Berkley, C. Marley Hill, Gateshead, Durham.
1886. ‡Bernard, W. Leigh. Calgary, Canada.
1887. §Berry, William. Parklands, Bowdon, Cheshire.
1870. ‡Berwick, George, M.D. 36 Fawcett-street, Sunderland.
1862. ‡Besant, William Henry, M.A., D.Sc., F.R.S. St. John's College, Cambridge.
1865. *Bessemer, Sir Henry, F.R.S. Denmark Hill, London, S.E.
1882. *Bessemer, Henry, jun. Town Hill Park, West End, Southampton.
1858. ‡Best, William. Leydon-terrace, Leeds.
1883. ‡Betley, Ralph, F.G.S. Mining School, Wigan.
1876. *Bettany, G. T., M.A., B.Sc., F.L.S., F.R.M.S. 33 Oakhurst-grove, East Dulwich-road, London, S.E.
1883. ‡Bettany, Mrs. 33 Oakhurst-grove, East Dulwich-road, London, S.E.
1880. *Bevan, Rev. James Oliver, M.A., F.G.S. The Vicarage, Vowchurch, Hereford.
1884. *Beverley, Michael, M.D. 54 Prince of Wales-road, Norwich.
1885. ‡Beveridge, R. Beath Villa, Ferryhill, Aberdeen.
1874. *Bevington, James B. Merle Wood, Sevenoaks.
1863. ‡Bewick, Thomas John, F.G.S. Suffolk House, Laurence Pountney Hill, London, E.C.
1844. *Bickerdike, Rev. John, M.A. Shireshead Vicarage, Garstang.
1886. §Bickersteth, The Very Rev. E., D.D., Dean of Lichfield. The Deanery, Lichfield.
1870. ‡Bickerton, A.W., F.C.S. Christchurch, Canterbury, New Zealand.
1888. *Bidder, George Parker. Trinity College, Cambridge.
1885. *Bidwell, Shelford, M.A., LL.B., F.R.S. Riverstone Lodge, Southfields, Wandsworth, Surrey, S.W.

Year of Election.

1882. §Biggs, C. H. W., F.C.S. Glebe Lodge, Champion Hill, London, S.E.
Bilton, Rev. William, M.A., F.G.S. United University Club, Suffolk-street, London, S.W.
1886. ‡Bindloss, G. F. Carnforth, Brondesbury Park, London, N.W.
1887. *Bindloss, James B. Elm Bank, Eccles, Manchester.
1884. *Bingham, John E. Electric Works, Sheffield.
1881. ‡Binnie, Alexander R., F.G.S. Town Hall, Bradford, Yorkshire.
1879. ‡*Binns, E. Knowles, F.R.G.S. 216 Heavygate-road, Sheffield.*
1873. ‡Binns, J. Arthur. Manningham, Bradford, Yorkshire.
1880. ‡Bird, Henry, F.C.S. South Down, near Devonport.
1866. **Birkin, Richard. Aspley Hall, near Nottingham.*
1888. *Birley, Miss Caroline. Seedley-terrace, Pendleton, Manchester.
1887. *Birley, H. K. 13 Hyde-road, Ardwick, Manchester.
1871. *Bischof, Gustav. 4 Hart-street, Bloomsbury, London, W.C.
1868. ‡*Bishop, John. Thorpe Hamlet, Norwich.*
1883. ‡Bishop, John le Marchant. 100 Mosley-street, Manchester.
1885. ‡Bissett, J. P. Wyndem, Banchory, N.B.
1886. *Bixby, Captain W. H. War Department, Washington, U.S.A.
1884. ‡Black, Francis, F.R.G.S. 6 North Bridge, Edinburgh.
1889. §Black, W. 1 Lovaine-place, Newcastle-upon-Tyne.
1889. §Black, William. 12 Romulus-terrace, Gateshead.
1881. §Black, Surgeon-Major William Galt, F.R.C.S.E. Caledonian United Service Club, Edinburgh.
1869. ‡Blackall, Thomas. 13 Southernhay, Exeter.
1834. Blackburn, Bewicke. Calverley Park, Tunbridge Wells.
1876. ‡Blackburn, Hugh, M.A. Roshven, Fort William, N.B.
1884. ‡Blackburn, Robert. New Edinburgh, Ontario, Canada.
Blackburne, Rev. John, jun., M.A. Rectory, Horton, near Chippenham.
1877. ‡Blackie, J. Alexander. 17 Stanhope-street, Glasgow.
1859. ‡Blackie, John S., M.A., Emeritus Professor of Greek in the University of Edinburgh. 9 Douglas-crescent, Edinburgh.
1876. ‡Blackie, Robert. 7 Great Western-terrace, Glasgow.
1855. *Blackie, W. G., Ph.D., F.R.G.S. 17 Stanhope-street, Glasgow.
1884. ‡Blacklock, Frederick W. 25 St. Famille-street, Montreal, Canada.
1883. ‡Blacklock, Mrs. Sea View, Lord-street, Southport.
1884. ‡*Blaikie, James, M.A. 14 Viewforth-place, Edinburgh.*
1888. ‡Blaine, R. S., J.P. Summerhill Park, Bath.
1883. ‡Blair, Mrs. Oakshaw, Paisley.
1863. ‡Blake, C. Carter, D.Sc. 4 Charlton-street, Fitzroy-square, London, W.
1886. ‡Blake, Dr. James. San Francisco, California.
1849. *Blake, Henry Wollaston, M.A., F.R.S., F.R.G.S. 8 Devonshire-place, Portland-place, London, W.
1883. *Blake, Rev. J. F., M.A., F.G S. 22 Newman-street, London, W.
1846. *Blake, William. Bridge House, South Petherton, Somerset.
1878. ‡Blakeney. Rev. Canon, M.A., D.D. The Vicarage, Sheffield.
1886. ‡Blakie, John. The Bridge House, Newcastle, Staffordshire.
1861. §Blakiston, Matthew, F.R.G.S. Free Hills, Burledon, Hants.
1887. §Blamires, George. Cleckheaton.
1881. §Blamires, Thomas H. Close Hill, Lockwood, near Huddersfield.
1884. *Blandy, William Charles, M.A. 1 Friar-street, Reading.
1869. ‡Blanford, W. T., LL.D., F.R.S., F.G.S., F.R.G.S. 72 Bedford-gardens, Campden Hill, London, W.
1887. *Bles, A. J. S. Moor End, Kersal, Manchester.
1887. *Bles, Edward J. Moor End, Kersal, Manchester.
1887. §Bles, Marcus S. The Beeches, Broughton Park, Manchester.
1884. *Blish, William G. Niles, Michigan, U.S.A.

Year of Election.

1869. *Blomefield, Rev. Leonard, M.A., F.L.S., F.G.S. 19 Belmont, Bath.
1880. §Bloxam, G. W., M.A., F.L.S. Thorpe Green, Chertsey.
1888. §Bloxsom, M. 73 Clarendon-road, Crumpsall, Manchester.
1883. ‡Blumberg, Dr. 65 Hoghton-street, Southport.
1870. ‡Blundell, Thomas Weld. Ince Blundell Hall, Great Crosby, Lancashire.
1859. ‡Blunt, Sir Charles, Bart. Heathfield Park, Sussex.
1859. ‡Blunt, Captain Richard. Bretlands, Chertsey, Surrey.
1885. §Blyth, James, M.A., F.R.S.E., Professor of Natural Philosophy in Anderson's College, Glasgow.
Blyth, B. Hall. 135 George-street, Edinburgh.
1883. ‡Blyth, Miss Phœbe. 3 South Mansion House-road, Edinburgh.
1887. ‡Blythe, William S. 65 Mosley-street, Manchester.
1867. ‡Blyth-Martin, W. Y. Blyth House, Newport, Fife.
1870. ‡Boardman, Edward. Queen-street, Norwich.
1887. *Boddington, Henry. Pownall Hall, Wilmslow, Manchester.
1889. §Bodmer, G. R., Assoc.M.Inst.C.E. 10 Westwick-gardens, West Kensington Park, London, W.
1884. ‡Body, Rev. C. W. E., M.A. Trinity College, Toronto, Canada.
1871. ‡Bohn, Mrs. North End House, Twickenham.
1887. *Boissevain, Gideon Maria. 4 Jesselschade-straat, Amsterdam.
1881. ‡Bojanowski, Dr. Victor de. 27 Finsbury-circus, London, E.C.
1876. ‡Bolton, J. C. Carbrook, Stirling.
Bond, Henry John Hayes, M.D. Cambridge.
1883. §Bonney, Frederic, F.R.G.S. Colton House, Rugeley, Staffordshire.
1883. §Bonney, Miss S. 23 Denning-road, Hampstead, London, N.W.
1871. *Bonney, Rev. Thomas George, D.Sc., LL.D., F.R.S., F.S.A., F.G.S., Professor of Geology in University College, London. 23 Denning-road, Hampstead, London, N.W.
1866. ‡Booker, W. H. Cromwell-terrace, Nottingham.
1888. §Boon, William. Coventry.
1883. §Booth, James. Hazelhurst House, Turton.
1883. ‡Booth, Richard. 4 Stone-buildings, Lincoln's Inn, London, W.C.
1876. ‡Booth, Rev. William H. St. Germain's-place, Blackheath, London, S.E.
1883. ‡Boothroyd, Benjamin. Rawlinson-road, Southport.
1876. *Borland, William. 260 West George-street, Glasgow.
1882. §Borns, Henry, Ph.D., F.C.S. Friedheim, Springfield-road, Wimbledon, Surrey.
1876. **Bosanquet, R. H. M., M.A., F.C.S., F.R.A.S. St. John's College, Oxford.*
*Bossey, Francis, M.D. Mayfield, Oxford-road, Redhill, Surrey.
1881. §Bothamley, Charles H. Yorkshire College, Leeds.
1867. §Botly, William, F.S.A. Salisbury House, Hamlet-road, Upper Norwood, London, S.E.
1887. ‡Bott, Dr. Owens College, Manchester.
1872. ‡Bottle, Alexander. Dover.
1868. ‡Bottle, J. T. 28 Nelson-road, Great Yarmouth.
1887. ‡Bottomley, James, D.Sc., B.A. 220 Lower Broughton-road, Manchester.
1871. *Bottomley, James Thomson, M.A., F.R.S., F.R.S.E., F.C.S. 13 University-gardens, Glasgow.
1884. *Bottomley, Mrs. 13 University-gardens, Glasgow.
1876. ‡Bottomley, William, jun. 6 Rokeley-terrace, Hillhead, Glasgow.
1883. §Bourdas, Isaiah. 59 Belgrave-road, London, S.W.

Year of Election.

1883. †Bourne, A. G., D.Sc., F.L.S., Professor of Zoology in the Presidency College, Madras.
1889. §Bourne, R. H. Fox. 41 Priory-road, Bedford Park, London, W.
1866. §Bourne, Stephen, F.S.S. Abberley, Wallington, Surrey.
1884. §Bovey, Henry T., M.A., Professor of Civil Engineering and Applied Mechanics in McGill University, Montreal. Ontario-avenue, Montreal, Canada.
1888. †Bowden, Rev. G. New Kingswood School, Lansdown, Bath.
1870. ‡Bower, Anthony. Bowersdale, Seaforth, Liverpool.
1881. *Bower, F. O., F.L.S., Professor of Botany in the University of Glasgow.
1867. ‡Bower, Dr. John. Perth.
1856. *Bowlby, Miss F. E. 23 Lansdowne-parade, Cheltenham.
1886. †Bowlby, Rev. Canon. 101 Newhall-street, Birmingham.
1884. ‡Bowley, Edwin. Burnt Ash Hill, Lee, Kent.
1880. ‡Bowly, Christopher. Cirencester.
1887. ‡Bowly, Mrs. Christopher. Cirencester.
1865. §Bowman, F. H., D.Sc., F.R.S.E. Halifax, Yorkshire.
Bowman, Sir William, Bart., M.D., LL.D., F R.S., F.R.C.S. 5 Clifford-street, London, W.
1887. §Box, Alfred M. Scissett, near Huddersfield.
1863. †Boyd, Edward Fenwick. Moor House, near Durham.
1884. *Boyd, M. A., M.D. 30 Merrion-square, Dublin.
1887. †Boyd, Robert. Manor House, Didsbury, Manchester.
1871. ‡Boyd, Thomas J. 41 Moray-place, Edinburgh.
1865. ‡Boyle, The Very Rev. G. D., M.A., Dean of Salisbury. The Deanery, Salisbury.
1884. *Boyle, R. Vicars, C.S.I. Care of Messrs. Grindlay & Co., 55 Parliament-street, London, S.W.
1872. *Brabrook, E. W., F.S.A. 28 Abingdon-street, Westminster, S.W.
1869. *Braby, Frederick, F.G.S., F.C.S. Bushey Lodge, Teddington, Middlesex.
1884. *Brace, W. H., M.D. 7 Queen's Gate-terrace, London, S.W.
1857. *Brady, Cheyne, M.R.I.A. Trinity Vicarage, West Bromwich.
1863. ‡Brady, George S., M.D., LL.D., F.R.S., F.L.S., Professor of Natural History in the Durham College of Science, Newcastle-on-Tyne. 2 Mowbray-villas, Sunderland.
1862. ‡Brady, Henry Bowman, LL.D., F.R.S., F.L.S., F.G.S. 5 Robert-street, Adelphi, London, W.C.
1880. *Brady, Rev. Nicholas, M.A. Rainham Hall, Rainham, Romford, Essex.
1864. §Braham, Philip, F.C.S. Bath.
1870. †Braidwood, Dr. 35 Park-road South, Birkenhead.
1888. §Braikenridge, W. J., J.P. 16 Royal-crescent, Bath.
1879. †Bramley, Herbert. 6 Paradise-square, Sheffield.
1865. §Bramwell, Sir Frederick J., Bart., D.C.L., F.R.S., M.Inst.C.E. 5 Great George-street, London, S.W.
1872. ‡Bramwell, William J. 17 Prince Albert-street, Brighton.
1867. ‡Brand, William. Milnefield, Dundee.
1861. *Brandreth, Rev. Henry. Dickleburgh Rectory, Scole, Norfolk.
1885. *Bratby, W. Pott-street, Ancoats, Manchester.
1852. ‡Brazier, James S., F.C.S., Professor of Chemistry in Marischal College and University of Aberdeen.
1868. ‡Bremridge, Elias. 17 Bloomsbury-square, London, W.C.
1877. ‡Brent, Francis. 19 Clarendon-place, Plymouth.
1882. *Bretherton, C. E. 1 Garden-court, Temple, London, E.C.
1881. *Brett, Alfred Thomas, M.D. Watford House, Watford.

Year of Election.

1866. ‡Brettell, Thomas (Mine Agent). Dudley.
1875. ‡Briant, T. Hampton Wick, Kingston-on-Thames.
1886. §Bridge, T. W., M.A., Professor of Zoology in the Mason Science College, Birmingham.
1884. ‡Bridges, C. J. Winnipeg, Canada.
1870. *Bridson, Joseph R. Sawrey, Windermere.
1887. ‡Brierley, John, J.P. The Clough, Whitefield, Manchester.
1870. ‡Brierley, Joseph. New Market-street, Blackburn.
1886. ‡Brierley, Leonard. Somerset-road, Edgbaston, Birmingham.
1879. ‡Brierley, Morgan. Denshaw House, Saddleworth.
1870. *BRIGG, JOHN. Broomfield, Keighley, Yorkshire.
1889. §Brigg, T. H. The Grange, Weston, near Otley, Yorkshire.
1866. *Briggs, Arthur. Cragg Royd, Rawdon, near Leeds.
1870. ‡Bright, H. A., M.A., F.R.G.S. Ashfield, Knotty Ash.
1868. ‡Brine, Captain Lindesay, F.R.G.S. United Service Club, Pall Mall, London, S.W.
1884. ‡Brisette, M. H. 424 St. Paul-street, Montreal, Canada.
1879. ‡Brittain, Frederick. Taptonville-crescent, Sheffield.
1879. *BRITTAIN, W. H. Storth Oaks, Ranmoor, Sheffield.
1878. ‡Britten, James, F.L.S. Department of Botany, British Museum, London, S.W.
1884. *Brittle, John R., M.Inst.C.E., F.R.S.E. Farad Villa, Vanbrugh Hill, Blackheath, London, S.E.
1859. *BRODHURST, BERNARD EDWARD, F.R.C.S., F.L.S. 20 Grosvenor-street, Grosvenor-square, London, W.
1883. *Brodie, David, M.D. 12 Patten-road, Wandsworth Common, S.W.
1865. ‡BRODIE, Rev. PETER BELLINGER, M.A., F.G.S. Rowington Vicarage, near Warwick.
1884. ‡Brodie, William, M.D. 64 Lafayette-avenue, Detroit, Michigan, U.S.A.
1883. *Brodie-Hall, Miss W. L. The Gore, Eastbourne.
1878. *Brook, George, F.L.S. The University, Edinburgh.
1881. §Brook, Robert G. Rowen-street, St. Helens, Lancashire.
1855. ‡Brooke, Edward. Marsden House, Stockport, Cheshire.
1864. *Brooke, Rev. Canon J. Ingham. Thornhill Rectory, Dewsbury.
1855. ‡Brooke, Peter William. Marsden House, Stockport, Cheshire.
1888. ‡Brooke, Rev. Canon R. E., M.A. 14 Marlborough-buildings, Bath.
1878. ‡Brooke, Sir Victor, Bart., F.L.S. Colebrook, Brookeborough, Co. Fermanagh.
1887. §Brooks, James Howard. Green Bank, Monton, Eccles, Manchester.
1863. ‡Brooks, John Crosse. 14 Lovaine-place, Newcastle-on-Tyne.
1887. ‡Brooks, S. H. Slade House, Levenshulme, Manchester.
1846. *Brooks, Thomas. Cranshaw Hall, Rawtenstall, Manchester.
1887. *Bros, W. Law. Sidcup, Kent.
1883. §Brotherton, E. A. Fern Cliffe, Ilkley, Leeds.
1886. §Brough, Joseph. University College, Aberystwith.
1885. *Browett, Alfred. 14 Dean-street, Birmingham.
1863. *BROWN, ALEXANDER CRUM, M.D., F.R.S. L. & E., F.C.S., Professor of Chemistry in the University of Edinburgh. 8 Belgrave-crescent, Edinburgh.
1867. ‡Brown, Charles Gage, M.D., C.M.G. 88 Sloane-street, London, S.W.
1855. ‡Brown, Colin. 192 Hope-street, Glasgow.
1871. ‡Brown, David. 93 Abbey-hill, Edinburgh.
1863. *Brown, Rev. Dixon. Unthank Hall, Haltwhistle, Carlisle.
1883. §Brown, Mrs. Ellen F. Campbell. 27 Abercromby-square, Liverpool.
1881. ‡Brown, Frederick D. 26 St. Giles's-street, Oxford.

Year of Election.

1887. ‡Brown, George. Cadishead, near Manchester.
1883. ‡Brown, George Dransfield. Henley Villa, Ealing, Middlesex, W.
1884. ‡Brown, Gerald Culmer. Lachute, Quebec, Canada.
1883. ‡Brown, Mrs. H. Bienz. 26 Ferryhill-place, Aberdeen.
1884. †Brown, Harry. University College, London, W.C.
1883. ‡Brown, Mrs. Helen. 52 Grange Loan, Edinburgh.
1870. §Brown, Horace T., F.R.S., F.C.S. 47 High-street, Burton-on-Trent.
Brown, Hugh. Broadstone, Ayrshire.
1883. †Brown, Miss Isabella Spring. 52 Grange Loan, Edinburgh.
1870. *Brown, Professor J. Campbell, D.Sc., F.C.S. University College, Liverpool.
1876. §Brown, John. Belair, Windsor-avenue, Belfast.
1881. *Brown, John, M.D. 68 Bank-parade, Burnley, Lancashire.
1882. *Brown, John. Swiss Cottage, Park-valley, Nottingham.
1859. ‡Brown, Rev. John Crombie, LL.D., F.L.S. Haddington, N.B.
1882. *Brown, Mrs. Mary. 68 Bank-parade, Burnley, Lancashire.
1885. ‡*Brown Miss. Springfield House, Ilkley, Yorkshire.*
1886. §Brown R., R.N. Laurel Bank, Barnhill, Perth.
1863. ‡Brown, Ralph. Lambton's Bank, Newcastle-upon-Tyne.
1871. ‡Brown, Robert, M.A., Ph.D., F.L.S., F.R.G.S. Fersley, Rydal-road, Streatham, London, S.W.
1868. †Brown, Samuel, M.Inst.C.E., Government Engineer. Nicosia, Cyprus.
1850. ‡Brown, William, F.R.S.E. 25 Dublin-street, Edinburgh.
1865. ‡Brown, William. 41a New-street, Birmingham.
1885. ‡Brown, W. A. The Court House, Aberdeen.
1884. ‡Brown, William George. Ivy, Albemarle Co., Virginia, U.S.A.
1863. ‡Browne, Sir Benjamin Chapman, M.Inst.C.E. Westacres, Newcastle-upon-Tyne.
1879. ‡Browne, Sir J. Crichton, M.D., LL.D., F.R.S. L. & E. 7 Cumberland-terrace, Regent's Park, London, N.W.
1866. *Browne, Rev. J. H. Lowdham Vicarage, Nottingham.
1862. *Browne, Robert Clayton, M.A. Browne's Hill, Carlow, Ireland.
1872. ‡Browne, R. Mackley, F.G.S. Redcot, Bradbourne, Sevenoaks, Kent.
1865. *Browne, William, M.D. Heath Wood, Leighton Buzzard.
1887. ‡Brownell, T. W. 6 St. James's-square, Manchester.
1865. ‡Browning, John, F.R.A.S. 63 Strand. London, W.C.
1883. ‡Browning, Oscar, M.A. King's College, Cambridge.
1855. ‡Brownlee, James, jun. 30 Burnbank-gardens, Glasgow.
1889. §Bruce, J. Collingwood, LL.D., D.C.L., F.S.A. Framlington-place, Newcastle-upon-Tyne.
1863. *Brunel, H. M. 23 Delahay-street, Westminster, S.W.
1863. ‡Brunel, J. 23 Delahay-street, Westminster, S.W.
1875. *Brunlees, Sir James, F.R.S.E., F.G.S., M.Inst.C.E. 5 Victoria-street, Westminster, S.W.
1875. ‡Brunlees, John. 5 Victoria-street, Westminster, S.W.
1868. ‡Brunton, T. Lauder, M.D., D.Sc., F.R.S. 10 Stratford-place, Oxford-street, London, W.
1878. §Brutton, Joseph. Yeovil.
1886. *Bryan, G. H. Trumpington-road, Cambridge.
1884. ‡Bryce, Rev. Professor George. The College, Manitoba, Canada.
1859. ‡Bryson, William Gillespie. Cullen, Aberdeen.
1871. §Buchan, Alexander, M.A., LL.D., F.R.S.E., Sec. Scottish Meteorological Society. 72 Northumberland-street, Edinburgh.
1867. ‡Buchan, Thomas. Strawberry Bank, Dundee.
1885. *Buchan, William Paton. Fairyknowe, Cambuslang, N.B.
Buchanan, Archibald. Catrine, Ayrshire.

Year of Election.

Buchanan, D. C. 12 Barnard-road, Birkenhead, Cheshire.
1881. *Buchanan, John H., M.D. Sowerby, Thirsk.
1871. ‡Buchanan, John Young, M.A., F.R.S. L. & E. 10 Moray-place, Edinburgh.
1884. ‡Buchanan, W. Frederick. Winnipeg, Canada.
1883. ‡Buckland, Miss A. W. 54 Doughty-street, London, W.C.
1886. *Buckle, Edmund W. 23 Bedford-row, London, W.C.
1864. §Buckle, Rev. George, M.A. Wells, Somerset.
1865. *Buckley, Henry. 27 Wheeley's-road, Edgbaston, Birmingham.
1886. §Buckley, Samuel. 76 Clyde-road, Albert-park, Didsbury.
1884. *Buckmaster, Charles Alexander, M.A., F.C.S. Science and Art Department, South Kensington, London, S.W.
1880. ‡Buckney, Thomas, F.R.A.S. 53 Gower-street, London, W.C.
1869. ‡Bucknill, J. C., M.D., F.R.S. Ower Moigne, Dorchester.
1851. *Buckton, George Bowdler, F.R.S., F.L.S., F.C.S. Weycombe, Haslemere, Surrey.
1887. ‡Budenberg, C. F., B.Sc. Buckau Villa, Demesne-road, Whalley Range, Manchester.
1875. §Budgett, Samuel. Kirton, Albemarle-road, Beckenham, Kent.
1883. ‡Buick, Rev. George R., M.A. Cullybackey, Co. Antrim, Ireland.
1871. ‡Bulloch, Matthew. 4 Bothwell-street, Glasgow.
1881. ‡Bulmer, T. P. Mount-villas, York.
1883. ‡Bulpit, Rev. F. W. Crossens Rectory, Southport.
1865. ‡Bunce, John Mackray. 'Journal' Office, New-street, Birmingham.
1886. §Burbury, S. H. 1 New-square, Lincoln's Inn, London, W.C.
1842. *Burd, John. 5 Gower-street, London, W.C.
1875. ‡Burder, John, M.D. 7 South-parade, Bristol.
1869. ‡Burdett-Coutts, Baroness. 1 Stratton-street, Piccadilly, London, W.
1881. ‡Burdett-Coutts, W. L. A. B., M.P. 1 Stratton-street, Piccadilly, London, W.
1884. *Burland, Jeffrey H. 287 University-street, Montreal, Canada.
1888. ‡Burne, H. Holland. 28 Marlborough-buildings, Bath.
1883. *Burne, Colonel Sir Owen Tudor, K.C.S.I., C.I.E., F.R.G.S. 57 Sutherland-gardens, Maida Vale, London, W.
1876. ‡Burnet, John. 14 Victoria-crescent, Dowanhill, Glasgow.
1885. *Burnett, W. Kendall, M.A. The Grove, Kemnay, Aberdeenshire.
1877. ‡Burns, David. Alston, Carlisle.
1884. §Burns, Professor James Austin. Southern Medical College, Atlanta, Georgia, U.S.A.
1883. ‡Burr, Percy J. 20 Little Britain, London, E.C.
1887. ‡Burroughs, Eggleston, M.D. Snow Hill-buildings, London, E.C.
1881. §Burroughs, S. M. Snow Hill-buildings, London, E.C.
1883. *Burrows, Abraham. Greenhall, Atherton, near Manchester.
1860. ‡Burrows, Montague, M.A., Professor of Modern History, Oxford.
1888. §Burt, John Mowlem. 3 St. John's-gardens, Kensington, London, W.
1888. ‡Burt, Mrs. 3 St. John's-gardens, Kensington, London, W.
1866. *Burton, Frederick M., F.G.S. Highfield, Gainsborough.
1889. §Burton, Rev. R. Lingen. Zetland Club, Saltburn-by-the-Sea.
1887. *Bury, Henry. Trinity College, Cambridge.
1878. ‡Butcher, J. G., M.A. 22 Collingham-place, London, S.W.
1884. *Butcher, William Deane, M.R.C.S.Eng. Clydesdale, Windsor.
1884. ‡Butler, Matthew I. Napanee, Ontario, Canada.
1888. ‡Buttanshaw, Rev. John. 22 St. James's-square, Bath.
1884. *Butterworth, W. Greenhill, Church-lane, Harpurhey, Manchester.
1872. ‡Buxton, Charles Louis. Cromer, Norfolk.
1870. ‡*Buxton, David, Ph.D. 298 Regent-street, London, W.*
1883. ‡Buxton, Miss F. M. Newnham College, Cambridge.

Year of Election

1887. *Buxton, J. H. 'Guardian' Office, Manchester.
1868. ‡Buxton, S. Gurney. Catton Hall, Norwich.
1881. ‡Buxton, Sydney. 15 Eaton-place, London, S.W.
1883. ‡Buxton, Rev. Thomas, M.A. 19 Westcliffe-road, Birkdale, Southport.
1872. ‡Buxton, Sir Thomas Fowell, Bart., F.R.G.S. Warlies, Waltham Abbey, Essex.
1854. ‡BYERLEY, ISAAC, F.L.S. Seacombe, Cheshire.
1885. ‡Byres, David. 63 North Bradford, Aberdeen.
1852. ‡Byrne, Very Rev. James. Ergenagh Rectory, Omagh.
1883. §Byrom, John R. Mere Bank, Fairfield, near Manchester.
1875. ‡Byrom, W. Ascroft, F.G.S. 31 King-street, Wigan.

1889. §Cackett, James Thoburn. 60 Larkspur-terrace, Newcastle-upon-Tyne.
1863. ‡Cail, Richard. Beaconsfield, Gateshead.
1863. ‡Caird, Edward. Finnart, Dumbartonshire.
1876. ‡Caird, Edward B. 8 Scotland-street, Glasgow.
1861. *Caird, James Key. 8 Magdalene-road, Dundee.
1875. ‡Caldicott, Rev. J. W., D.D. The Rectory, Shipston-on-Stour.
1886. *Caldwell, William Hay. Birnam, Chaucer-road, Cambridge.
1868. ‡Caley, A. J. Norwich.
1857. ‡Callan, Rev. N. J., Professor of Natural Philosophy in Maynooth College.
1887. ‡CALLAWAY CHARLES, M.A., D.Sc., F.G.S. Sandon, Wellington, Shropshire.
1854. ‡Calver, Captain E. K., R.N., F.R.S. 23 Park-place East, Sunderland, Durham.
1884. ‡Cameron, Æneas. Yarmouth, Nova Scotia, Canada.
1876. ‡Cameron, Charles, M.D., LL.D., M.P. 1 Huntly-gardens, Glasgow.
1857. ‡CAMERON, Sir CHARLES A., M.D. 15 Pembroke-road, Dublin.
1884. ‡Cameron, James C., M.D. 41 Belmont-park, Montreal, Canada.
1870. ‡Cameron, John, M.D. 17 Rodney-street, Liverpool.
1884. ‡Campbell, Archibald H. Toronto, Canada.
1874. *CAMPBELL, Sir GEORGE, K.C.S.I., M.P., D.C.L., F.R.G.S., F.S.S. Southwell House, Southwell-gardens, South Kensington, London, S.W.; and Edenwood, Cupar, Fife.
1883. ‡Campbell, H. J. 81 Kirkstall-road, Talfourd Park, Streatham Hill, S.W.
Campbell, Sir Hugh P. H., Bart. 10 Hill-street, Berkeley-square, London, W.; and Marchmont House, near Dunse, Berwickshire.
1876. ‡Campbell, James A., LL.D., M.P. Stracathro House, Brechin.
Campbell, John Archibald, M.D., F.R.S.E. Albyn-place, Edinburgh.
1862. *CAMPION, Rev. WILLIAM M., D.D. Queen's College, Cambridge.
1882. ‡Candy, F. H. 71 High-street, Southampton.
1888. ‡Cappel, Sir Albert J. L., K.C.I.E. 14 Harrington-gardens, London, W.
1880. ‡*Capper, Robert. Westbrook, Swansea.*
1883. ‡*Capper, Mrs. R. Westbrook, Swansea.*
1887. ‡Capstick, John Walton. University College, Dundee.
1873. *CARBUTT, EDWARD HAMER, M.Inst.C.E. 19 Hyde Park-gardens, London, W.
1883. ‡Carey-Hobson, Mrs. 54 Doughty-street, London, W.C.
1877. ‡Carkeet, John. 3 St. Andrew's-place, Plymouth.
CARLISLE, The Right Rev. HARVEY GOODWIN, D.D., D.C.L., Lord Bishop of. Carlisle.

Year of Election.

1867. ‡Carmichael, David (Engineer). Dundee.
1867. ‡Carmichael, George. 11 Dudhope-terrace, Dundee.
1876. ‡Carmichael, Neil, M.D. 22 South Cumberland-street, Glasgow.
1884. ‡Carnegie, John. Peterborough, Ontario, Canada.
1885. *CARNELLEY, THOMAS, D.Sc., Professor of Chemistry in University College, Dundee.
1887. ‡Carpenter, A., M.D. Duppas House, Croydon.
1884. §Carpenter, Louis G. Agricultural College, Lansing, Michigan, U.S.A.
1871. *CARPENTER, P. HERBERT, D.Sc., F.R.S. Eton College, Windsor.
1854. ‡Carpenter, Rev. R. Lant, B.A. Bridport.
1872. §CARPENTER, WILLIAM LANT, B.A., B.Sc., F.C.S. 36 Craven-park, Harlesden, London, N.W
1888. *Carpmael, Alfred. 1 Copthall-buildings, London, E.C.
1884. *Carpmael, Charles. Toronto, Canada.
1889. §Carr, Cuthbert Ellison. Hedgeley, Alnwick.
1889. §Carr-Ellison, John Ralph. Hedgeley, Alnwick.
1867. ‡CARRUTHERS, WILLIAM, Pres.L.S., F.R.S., F.G.S. British Museum, London, S.W.
1886. ‡CARSLAKE, J. BARHAM. 30 Westfield-road, Birmingham.
1883. ‡Carson, John. 51 Royal Avenue, Belfast.
1861. *Carson, Rev. Joseph, D.D., M.R.I.A. 18 Fitzwilliam-place, Dublin.
1868. ‡Carteighe, Michael, F.C.S. 172 New Bond-street, London, W.
1866. ‡Carter, H. H. The Park, Nottingham.
1855. ‡Carter, Richard, F.G.S. Cockerham Hall, Barnsley, Yorkshire.
1870. ‡Carter, Dr. William. 78 Rodney-street, Liverpool.
1883. ‡Carter, W. C. Manchester and Salford Bank, Southport.
1883. ‡Carter, Mrs. Manchester and Salford Bank, Southport.
1878. *Cartwright, E. Henry. Magherafelt Manor, Co. Derry.
1870. §Cartwright, Joshua, M.Inst.C.E., Borough Surveyor. Bury, Lancashire.
1884. *Carver, Rev. Canon Alfred J., D.D., F.R.G.S. Lynnhurst, Streatham Common, London, S.W.
1884. ‡Carver, Mrs. Lynnhurst, Streatham Common, London, S.W.
1883. ‡Carver, James. Garfield House, Elm-avenue, Nottingham.
1887. ‡Casartelli, Rev. L. C., M.A., Ph.D. St. Bede's College, Manchester.
1866. ‡Casella, L. P., F.R.A.S. The Lawns, Highgate, London, N.
1878. ‡Casey, John, LL.D., F.R.S., M.R.I.A., Professor of Higher Mathematics in the Catholic University of Ireland. 86 South Circular-road, Dublin.
1871. ‡Cash, Joseph. Bird-grove, Coventry.
1873. *Cash, William, F.G.S. 38 Elmfield-terrace, Saville Park, Halifax.
Castle, Charles. Clifton, Bristol.
1888. ‡Cater, R. B. Avondale, Henrietta Park, Bath.
1874. ‡Caton, Richard, M.D., Lecturer on Physiology at the Liverpool Medical School. Lea Hall, Gateacre, Liverpool.
1859. ‡Catto, Robert. 44 King-street, Aberdeen.
1884. **Cave, Herbert. Christ Church, Oxford.*
1887. §Cawley, George. 3 Lansdowne-road, Didsbury, Manchester.
1886. ‡Cay, Albert. Ashleigh, Westbourne-road, Birmingham.
1860. §CAYLEY, ARTHUR, M.A., D.C.L., LL.D., D.Sc., F.R.S., V.P.R.A.S., Sadlerian Professor of Pure Mathematics in the University of Cambridge. Garden House, Cambridge.
Cayley, Digby. Brompton, near Scarborough.
Cayley, Edward Stillingfleet. Wydale, Malton, Yorkshire.
1871. *Cecil, Lord Sackville. Hayes Common, Beckenham, Kent.
1860. ‡CHADWICK, DAVID. The Poplars, Herne Hill, London, S.E.

Year of Election.

1842. CHADWICK, Sir EDWIN, K.C.B. Park Cottage, East Sheen, Surrey, S.W.
1883. ‡Chadwick, James Percy. 51 Alexandra-road, Southport.
1859. ‡Chadwick, Robert. Highbank, Manchester.
1883. ‡Chalk, William. 24 Gloucester-road, Birkdale, Southport.
1859. ‡Chalmers, John Inglis. Aldbar, Aberdeen.
1883. ‡Chamberlain, George, J.P. Helensholme, Birkdale Park, Southport.
1884. ‡Chamberlain, Montague. St. John, New Brunswick, Canada.
1883. ‡CHAMBERS, CHARLES, F.R.S. Colába Observatory, Bombay.
1883. ‡Chambers, Mrs. Colába Observatory, Bombay.
1842. Chambers, George. High Green, Sheffield.
1868. ‡Chambers, W. O. Lowestoft, Suffolk.
*Champney, Henry Nelson. 4 New-street, York.
1881. *Champney, John E. Woodlands, Halifax.
1865. ‡Chance, A. M. Edgbaston, Birmingham.
1865. *Chance, James T. 51 Prince's-gate, London, S.W.
1886. *Chance, John Horner. 40 Augustus-road, Edgbaston, Birmingham.
1865. ‡Chance, Robert Lucas. Chad Hill, Edgbaston, Birmingham.
1888. §Chandler, S. Whitty, B.A. Sherborne, Dorset.
1861. *Chapman, Edward, M.A., F.L.S., F.C.S. Hill End, Mottram, Manchester.
1889. §Chapman, L. H. 147 Park-road, Newcastle-upon-Tyne.
1884. ‡Chapman, Professor. University College, Toronto, Canada.
1877. §Chapman, T. Algernon, M.D. Burghill, Hereford.
1874. ‡*Charles, John James, M.A., M.D.* 11 *Fisherwick-place, Belfast.*
1836. CHARLESWORTH, EDWARD, F.G.S. 277 Strand, London, W.C.
1874. ‡Charley, William. Seymour Hill, Dunmurry, Ireland.
1866. ‡CHARNOCK, RICHARD STEPHEN, Ph.D., F.S.A., F.R.G.S. Junior Garrick Club, Adelphi-terrace, London, W.C.
1886. ‡Chate, Robert W. Southfield, Edgbaston, Birmingham.
1883. ‡Chater, Rev. John. Part-street, Southport.
1884. *Chatterton, George, M.A., M.Inst.C.E. 46 Queen Anne's-gate, London, S.W.
1886. §Chattock, A. P. 15 Lancaster-road, Belsize Park, London, N.W.
1867. *Chatwood, Samuel, F.R.G.S. Irwell House, Drinkwater Park, Prestwich.
1884. ‡CHAUVEAU, The Hon. Dr. Montreal, Canada.
1883. ‡Chawner, W., M.A. Emmanuel College, Cambridge.
1864. ‡CHEADLE, W. B., M.A., M.D., F.R.G.S. 2 Hyde Park-place, Cumberland-gate, London, S.W.
1887. §Cheetham, F. W. Limefield House, Hyde.
1887. ‡Cheetham, John. Limefield House, Hyde.
1874. *Chermside, Lieut.-Colonel H. C., R.E., C.B. Care of Messrs. Cox & Co., Craig's-court, Charing Cross, London, S.W.
1884. ‡Cherriman, Professor J. B. Ottawa, Canada.
1879. *Chesterman, W. Broomsgrove-road, Sheffield.
CHICHESTER, The Right Rev. RICHARD DURNFORD, D.D., Lord Bishop of. Chichester.
1865. *Child, Gilbert W., M.A., M.D., F.L.S. Cowley House, Oxford.
1883. §Chinery, Edward F. Monmouth House, Lymington.
1884. ‡Chipman, W. W. L. 6 Place d'Armes, Ontario, Canada.
1889. §Chirney, J. W. Morpeth.
1842. *Chiswell, Thomas. 17 Lincoln-grove, Plymouth-grove, Manchester.
1863. ‡Cholmeley, Rev. C. H. The Rectory, Beaconsfield R.S.O., Bucks.
1882. ‡Chorley, George. Midhurst, Sussex.
1887. ‡Chorlton, J. Clayton. New Holme, Withington, Manchester.
1861. ‡Christie, Professor R. C., M.A. 7 St. James's-square, Manchester.

Year of Election

1884. *Christie, William. 13 Queen's Park, Toronto, Canada.
1875. *Christopher, George, F.C.S. 6 Barrow-road, Streatham Common, London, S.W.
1876. *CHRYSTAL, GEORGE, M.A., F.R.S.E., Professor of Mathematics in the University of Edinburgh. 5 Belgrave-crescent, Edinburgh.
1870. §CHURCH, A. H., M.A., F.R.S., F.C.S., Professor of Chemistry to the Royal Academy of Arts, London. Shelsley, Ennerdale-road, Kew, Surrey.
1860. ‡Church, William Selby, M.A. St. Bartholomew's Hospital, London, E.C.
1881. ‡CHURCHILL, Lord ALFRED SPENCER. 16 Rutland-gate, London, S.W.
1857. ‡Churchill, F., M.D. Ardtrea Rectory, Stewartstown, Co. Tyrone.
1868. ‡Clabburn, W. H. Thorpe, Norwich.
1857. ‡Clarendon, Frederick Villiers. 1 Belvidere-place, Mountjoy-square, Dublin.
1876. ‡Clark, David R., M.A. 31 Waterloo-street, Glasgow.
1877. *Clark, F. J. Street, Somerset.
Clark, George T. 44 Berkeley-square, London, W.
1876. ‡Clark, George W. 31 Waterloo-street, Glasgow.
1876. ‡Clark, Dr. John. 138 Bath-street, Glasgow.
1881. ‡Clark, J. Edmund, B.A., B.Sc., F.G.S. 20 Bootham, York.
1861. ‡Clark, Latimer, F.R.S., M.Inst.C.E. 11 Victoria-street, London, S.W.
1855. ‡Clark, Rev. William, M.A. Barrhead, near Glasgow.
1883. ‡Clarke, Rev. Canon, D.D. 59 Hoghton-street, Southport.
1887. §Clarke, C. Goddard. Folkestone Villa, Elm-grove, Peckham, S.E.
1865. ‡Clarke, Rev. Charles. Charlotte-road, Edgbaston, Birmingham.
1875. ‡Clarke, Charles S. 4 Worcester-terrace, Clifton, Bristol.
1886. ‡Clarke, David. Langley-road, Small Heath, Birmingham.
Clarke, George. Mosley-street, Manchester.
1886. §Clarke, Rev. H. J. Great Barr Vicarage, Birmingham.
1872. *CLARKE, HYDE. 32 St. George's-square, Pimlico, London, S.W.
1875. ‡CLARKE, JOHN HENRY. 4 Worcester-terrace, Clifton, Bristol.
1861. *Clarke, John Hope. 62 Nelson-street, Chorlton-on-Medlock, Manchester.
1877. ‡Clarke, Professor John W. University of Chicago, Illinois, U.S.A.
1851. ‡CLARKE, JOSHUA, F.L.S. Fairycroft, Saffron Walden.
Clarke, Thomas, M.A. Knedlington Manor, Howden, Yorkshire.
1883. ‡Clarke, W. P., J.P. 15 Hesketh-street, Southport.
1884. ‡Claxton, T. James. 461 St. Urbain-street, Montreal, Canada.
1861. ‡Clay, Charles, M.D. 101 Piccadilly, Manchester.
*Clay, Joseph Travis, F.G.S. Rastrick, near Brighouse, Yorkshire.
1889. §Clayden, A. W. Warleigh, Palace-road, Tulse Hill Park, London, S.W.
1866. ‡Clayden, P. W. 13 Tavistock-square, London, W.C.
1850. ‡CLEGHORN, HUGH, M.D., F.L.S. Stravithie, St. Andrews, Scotland.
1859. ‡Cleghorn, John. Wick.
1875. ‡Clegram, T. W. B. Saul Lodge, near Stonehouse, Gloucestershire.
1861. §CLELAND, JOHN, M.D., D.Sc., F.R.S., Professor of Anatomy in the University of Glasgow. 2 College, Glasgow.
1873. ‡Cliff, John, F.G.S. Nesbit Hall, Fulneck, Leeds.
1886. ‡Clifford, Arthur. Beechcroft, Edgbaston, Birmingham.
1883. ‡*Clift, Frederic, LL.D. Norwood, Surrey.*
1888. ‡CLIFTON, The Right Rev. the Bishop of, D.D. Bishop's House, Clifton, Bristol.

Year of Election.

1861. *CLIFTON, R. BELLAMY, M.A., F.R.S., F.R.A.S., Professor of Experimental Philosophy in the University of Oxford. Portland Lodge, Park Town, Oxford.
Clonbrock, Lord Robert. Clonbrock, Galway.
1878. §Close, Rev. Maxwell H., F.G.S. 40 Lower Baggot-street, Dublin.
1873. ‡Clough, John. Bracken Bank, Keighley, Yorkshire.
1883. *CLOWES, FRANK, D.Sc., F.C.S., Professor of Chemistry in University College, Nottingham. University College, Nottingham.
1863. *Clutterbuck, Thomas. Warkworth, Acklington.
1881. *Clutton, William James. The Mount, York.
1885. ‡Clyne James. Rubislaw Den South, Aberdeen.
1868. ‡Coaks, J. B. Thorpe, Norwich.
1855. *Coats, Sir Peter. Woodside, Paisley.
Cobb, Edward. Falkland House, St. Ann's, Lewes.
1884. §Cobb, John. 29 Clarendon-road, Leeds.
1889. §Cochrane, Cecil A. Oakfield House, Gosforth, Newcastle-upon-Tyne.
1864. *Cochrane, James Henry. Elm Lodge, Prestbury, Cheltenham.
1889. §Cochrane, William. Oakfield House, Gosforth, Newcastle-upon-Tyne.
1883. ‡Cockshott, J. J. 24 Queen's-road, Southport.
1861. *Coe, Rev. Charles C., F.R.G S. Fairfield, Heaton, Bolton.
1881. *COFFIN, WALTER HARRIS, F.C.S. 94 Cornwall-gardens, South Kensington, London, S.W.
1865. ‡Coghill, H. Newcastle-under-Lyme.
1884. *Cohen, B. L. 30 Hyde Park-gardens, London, W.
1887. §Cohen, Julius B. Hawkesmoor, Wilbraham-road, Fallowfield, Manchester.
1887. ‡Cohen, Sigismund. 111 Portland-street, Manchester.
1853. ‡Colchester, William, F.G.S. Springfield House, Ipswich.
1868. ‡Colchester, W. P. Bassingbourn, Royston.
1879. ‡Cole, Skelton. 387 Glossop-road, Sheffield.
1878. ‡Coles, John, Curator of the Map Collection R.G.S. 1 Savile-row, London, W.
1854. *Colfox, William, B.A. Westmead, Bridport, Dorsetshire.
1857. ‡Colles, William, M.D. 21 Stephen's-green, Dublin.
1887. ‡Collie, Norman. University College, Gower-street, London, W.C.
1887. ‡Collier, Thomas. Ashfield, Alderley Edge, Manchester.
1869. ‡Collier, W. F. Woodtown, Horrabridge, South Devon.
1854. ‡COLLINGWOOD, CUTHBERT, M.A., M.B., F.L.S. 2 Gipsy Hill-villas, Upper Norwood, Surrey, S.E.
1861. *Collingwood, J. Frederick, F.G.S. 96 Great Portland-street, London, W.
1865. *Collins, James Tertius. Churchfield, Edgbaston, Birmingham.
1876. ‡COLLINS, J. H., F.G.S. 4 Clark-terrace, Dulwich Rise, London, S.E.
1876. ‡Collins, Sir William. 3 Park-terrace East, Glasgow.
1884. §Collins, William J., M.D., B.Sc. Albert-terrace, Regent's Park, London, N.W.
1868. *COLMAN, J. J., M.P. Carrow House, Norwich; and 108 Cannon-street, London, E.C.
1882. ‡Colmer, Joseph G., C.M.G. Office of the High Commissioner for Canada, 9 Victoria-chambers, London, S.W.
1884. ‡Colomb, Sir J. C. R., M.P., F.R.G.S. Dromquinna, Kenmare, Kerry, Ireland; and Junior United Service Club, London, S.W.
1888. ‡Commans, R. D. Macaulay-buildings, Bath.
1884. ‡Common, A. A., F.R.S., F.R.A.S. 63 Eaton-rise, Ealing, Middlesex, W.
1884. §Conklin, Dr. William A. Central Park, New York, U.S.A.

Year of Election.

1852. ‡Connal, Sir Michael. 16 Lynedoch-terrace, Glasgow.
1871. *Connor, Charles C. Notting Hill House, Belfast.
1881. ‡CONROY, Sir JOHN, Bart. Balliol College, Oxford.
1876. ‡Cook, James. 162 North-street, Glasgow.
1882. ‡COOKE, Major-General A. C., R.E., C.B., F.R.G.S. Palace-chambers, Ryder-street, London, S.W.
1876. *COOKE, CONRAD W. 2 Victoria-mansions, Victoria-street, London, S.W.
1881. ‡Cooke, F. Bishopshill, York.
1868. ‡Cooke, Rev. George H. Wanstead Vicarage, near Norwich.
1868. ‡COOKE, M. C., M.A. 2 Grosvenor-villas, Upper Holloway, London, N.
1884. ‡Cooke, R. P. Brockville, Ontario, Canada.
1878. ‡Cooke, Samuel, M.A., F.G.S. Poona, Bombay.
1881. ‡Cooke, Thomas. Bishopshill, York.
1859. *Cooke, His Honour Judge, M.A., F.S.A. 42 Wimpole-street, London, W.; and Rainthorpe Hall, Long Stratton.
1883. ‡Cooke-Taylor, R. Whateley. Frenchwood House, Preston.
1883. ‡Cooke-Taylor, Mrs. Frenchwood House, Preston.
1865. ‡Cooksey, Joseph. West Bromwich, Birmingham.
1888. §Cooley, George Parkin. Cavendish Hill, Sherwood, Nottingham.
1883. ‡Coomer, John. Willaston, near Nantwich.
1884. ‡Coon, John S. 604 Main-street, Cambridge Pt., Massachusetts, U.S.A.
1883. ‡Cooper, George B. 67 Great Russell-street, London, W.C.
1850. ‡COOPER, Sir HENRY, M.D. 7 Charlotte-street, Hull.
1838. Cooper, James. 58 Pembridge-villas, Bayswater, London, W.
1884. ‡Cooper, Mrs. M. A. West Tower, Marple, Cheshire.
1868. ‡*Cooper, W. J. The Old Palace, Richmond, Surrey.*
1846. ‡*Cooper, William White, F.R.C.S.* 19 *Berkeley-square, London, W.*
1889. §Coote, Arthur. The Minories, Jesmond, Newcastle-upon-Tyne.
1884. ‡Cope, E. D. Philadelphia, U.S.A.
1878. ‡Cope, Rev. S. W. Bramley, Leeds.
1871. ‡Copeland, Ralph, Ph.D., F.R.A.S., Astronomer Royal for Scotland and Professor of Astronomy in the University of Edinburgh.
1885. ‡Copland, W., M.A. Tortorston, Peterhead, N.B.
1881. ‡Copperthwaite, H. Holgate Villa, Holgate-lane, York.
1863. ‡Coppin, John. North Shields.
1842. Corbett, Edward. Grange-avenue, Levenshulme, Manchester.
1887. *Corcoran, Bryan. 31 Mark-lane, London, E.C.
1881. §Cordeaux, John. Great Cotes, Ulceby, Lincolnshire.
1883. *Core, Thomas H. Fallowfield, Manchester.
1870. *CORFIELD, W. H., M.A., M.D., F.C.S., F.G.S., Professor of Hygiene and Public Health in University College. 19 Savile-row, London, W.
1889. §Cornish, Vaughan. Ivy Cottage, Newcastle, Staffordshire.
1884. *Cornwallis, F. S. W. Linton Park, Maidstone.
1885. ‡Corry, John. Rosenheim, Parkhill-road, Croydon.
1888. §Corser, Rev. Richard K. 12 Beaufort-buildings East, Bath.
1888. ‡Cossham, Handel, M.P., F.G.S. Weston Park, Bath.
1883. ‡Costelloe, B. F. C., M.A., B.Sc. 33 Chancery-lane, London, W.C.
Cottam, George. 2 Winsley-street, London, W.
1857. ‡Cottam, Samuel. King-street, Manchester.
1874. *COTTERILL, J. H., M.A., F.R.S., Professor of Applied Mechanics. Royal Naval College, Greenwich, S.E.
1864. ‡COTTON, General FREDERICK C., R.E., C.S.I. 13 Longridge-road, Earl's Court-road, London, S.W.
1869. ‡COTTON, WILLIAM. Pennsylvania, Exeter.

Year of Election.

1879. ‡Cottrill, Gilbert I. Shepton Mallett, Somerset.
1876. ‡Couper, James. City Glass Works, Glasgow.
1876. ‡Couper, James, jun. City Glass Works, Glasgow.
1874. ‡Courtauld, John M. Bocking Bridge, Braintree, Essex.
1889. §Courtney, F. S. 77 Redcliffe-square, South Kensington, London, S.W.
Cowan, John. Valleyfield, Pennycuick, Edinburgh.
1863. ‡Cowan, John A. Blaydon Burn, Durham.
1863. ‡Cowan, Joseph, jun. Blaydon, Durham.
1876. ‡Cowan, J. B., M.D. 4 Eglinton-crescent, Edinburgh.
1872. *Cowan, Thomas William, F.G S. Comptons Lea, Horsham.
1886. §Cowen, Mrs. G. R. 9 The Ropewalk, Nottingham.
Cowie, The Very Rev. Benjamin Morgan, M.A., D.D., Dean of Exeter. The Deanery, Exeter.
1871. ‡Cowper, C. E. 6 Great George-street, Westminster, S.W.
1860. ‡Cowper, Edward Alfred, M.Inst.C.E. 6 Great George-street, Westminster, S.W.
1867. *Cox, Edward. Lyndhurst, Dundee.
1867. *Cox, George Addison. Beechwood, Dundee.
1882. ‡Cox, Thomas A., District Engineer of the S., P., and D. Railway. Lahore, Punjab. Care of Messrs. Grindlay & Co., Parliament-street, London, S.W.
1867. *Cox, Thomas Hunter. Duncarse, Dundee.
1888. ‡Cox, Thomas W. B. The Chesnuts, Lansdown, Bath.
1867. ‡Cox, William. Foggley, Lochee, by Dundee.
1883. §Crabtree, William, M.Inst.C.E. Manchester-road, Southport.
1884. §CRAIGIE, Major P. G., F.S.S. 6 Lyndhurst-road, Hampstead, London, N.W.
1876. ‡Cramb, John. Larch Villa, Helensburgh, N.B.
1858. ‡Cranage, Edward, Ph.D. The Old Hall, Wellington, Shropshire.
1884. ‡Crathern, James. Sherbrooke-street, Montreal, Canada.
1887. §Craven, John. Smedley Lodge, Cheetham, Manchester.
1887. *Craven, Thomas, J.P. Merlewood, Chorlton-cum-Hardy, Manchester.
1876. ‡*Crawford, Chalmond. Ridemon, Crosscar.*
1871. *Crawford, William Caldwell, M.A. 1 Lockharton-gardens, Slateford, Edinburgh.
1871. *CRAWFORD AND BALCARRES, The Right Hon. the Earl of, LL.D. F.R.S., F.R.A.S. The Observatory, Dun Echt, Aberdeen.
1883. *Crawshaw, Edward. 25 Tollington-park, London, N
1870. *Crawshay, Mrs. Robert. Cathedine, Bwlch, Breconshire.
1885. §Creak, Staff Commander E. W., R.N., F.R.S. Richmond Lodge, Blackheath, London, S.E.
1879. ‡Creswick, Nathaniel. Chantry Grange, near Sheffield.
1888. §Crew, E. G. 20 Redland-park, Clifton, Bristol.
1876. *Crewdson, Rev. George. St. George's Vicarage, Kendal.
1887. *Crewdson, Theodore. Norcliffe Hall, Handforth, Manchester.
1880. *Crisp, Frank, B.A., LL.B., F.L.S. 5 Lansdowne-road, Notting Hill, London, W.
1878. ‡Croke, John O'Byrne, M.A. 12 Plevna-terrace, St. Mary's-road, Dublin.
1859. ‡*Croll, A. A.* 10 *Coleman-street, London, E.C.*
1857. ‡Crolly, Rev. George. Maynooth College, Ireland.
1885. ‡Crombie, Charles W. 41 Carden-place, Aberdeen.
1885. ‡Crombie, John. 129 Union-street, Aberdeen.
1885. ‡Crombie, John, jun. Daveston, Aberdeen.
1885. ‡CROMBIE, J. W., M.A. Balgownie Lodge, Aberdeen.

Year of Election.

1885. ‡Crombie, Theodore. 18 Albyn-place, Aberdeen.
1887. ‡Crompton, A. 1 St. James's-square, Manchester.
1886. ‡Crompton, Dickinson W. 40 Harborne-road, Edgbaston, Birmingham.
1887. §Crook, Henry T. 9 Albert-square, Manchester.
1870. ‡Crookes, Joseph. Marlborough House, Brook Green, Hammersmith, London, W.
1865. §Crookes, William, F.R.S., F.C.S. 7 Kensington Park-gardens, London, W.
1879. ‡Crookes, Mrs. 7 Kensington Park-gardens, London, W.
1855. *Cropper, Rev. John. 8 The Polygon, Eccles, near Manchester.
1870. ‡Crosfield, C. J. Holmfield, Aigburth, Liverpool.
1870. *Crosfield, William. Annesley, Aigburth, Liverpool.
1887. §Cross, John. Beancliffe, Alderley Edge, Cheshire.
1861. ‡Cross, Rev. John Edward, M.A. Appleby Vicarage, near Brigg.
1883. ‡Cross, Rev. Prebendary, LL.B. Part-street, Southport.
1868. ‡Crosse, Thomas William. St. Giles's-street, Norwich.
1886. ‡Crosskey, Cecil. 117 Gough-road, Birmingham.
1867. §Crosskey, Rev. H. W., LL.D., F.G.S. 117 Gough-road, Birmingham.
1853. ‡Crosskill, William. Beverley, Yorkshire.
1870. *Crossley, Edward, M.P., F.R.A.S. Bemerside, Halifax.
1871. ‡Crossley, Herbert. Ferney Green, Bowness, Ambleside.
1866. *Crossley, Louis J., F.R.M.S. Moorside Observatory, near Halifax.
1887. *Crossley, William J. Glenfield, Bowdon, Cheshire.
1883. §Crowder, Robert. Stanwix, Carlisle.
1882. §Crowley, Frederick. Ashdell, Alton, Hampshire.
1883. ‡Crowther, Elon. Cambridge-road, Huddersfield.
1863. ‡Cruddas, George. Elswick Engine Works, Newcastle-on-Tyne.
1885. ‡Cruickshank, Alexander, LL.D. 20 Rose-street, Aberdeen.
1859. ‡Cruickshank, Provost. Macduff, Scotland.
1888. §Crummack, William J. London and Brazilian Bank, Rio de Janeiro, Brazil.
1873. ‡Crust, Walter. Hall-street, Spalding.
1883. *Cryer, Major J. H. The Grove, Manchester-road, Southport.
Culley, Robert. Bank of Ireland, Dublin.
1883. *Culverwell, Edward P. 40 Trinity College, Dublin.
1878. ‡Culverwell, Joseph Pope. St. Lawrence Lodge, Sutton, Dublin.
1883. ‡Culverwell, T. J. H. Litfield House, Clifton, Bristol.
1859. ‡Cumming, Sir A. P. Gordon, Bart. Altyre.
1874. ‡Cumming, Professor. 33 Wellington-place, Belfast.
1861. *Cunliffe, Edward Thomas. The Parsonage, Handforth, Manchester.
1861. *Cunliffe, Peter Gibson. Dunedin, Handforth, Manchester.
1882. *Cunningham, Lieut.-Colonel Allan, R.E., A.I.C.E. C. R. E.'s Office, Dublin.
1887. ‡Cunningham, David, M.Inst.C.E., F.R.S.E., F.S.S. Harbour-chambers, Dundee; and Viewbank, Newport, Fife, Scotland.
1877. *Cunningham, D. J., M.D., Professor of Anatomy in Trinity College, Dublin.
1852. ‡Cunningham, John. Macedon, near Belfast.
1885. ‡Cunningham, J. T., B.A., F.R.S.E. Scottish Marine Station, Granton, Edinburgh.
1869. ‡Cunningham, Robert O., M.D., F.L.S., Professor of Natural History in Queen's College, Belfast.
1883. *Cunningham, Rev. William, D.D., D.Sc. Trinity College, Cambridge.
1850. ‡Cunningham, Rev. William Bruce. Prestonpans, Scotland.
1885. ‡Curphey, William S. 268 Renfrew-street, Glasgow.
1884. ‡Currier, John McNab. Newport, Vermont, U.S.A.

Year of Election.

1867. **Cursetjee, Manockjee, F.R.G.S., Judge of Bombay. Villa-Byculla, Bombay.*
1857. ‡CURTIS, ARTHUR HILL, LL.D. 1 Hume-street, Dublin.
1878. ‡Curtis, William. Caramore, Sutton, Co. Dublin.
1884. ‡Cushing, Frank Hamilton. Washington, U.S.A.
1883. ‡Cushing, Mrs. M. Croydon, Surrey.
1881. §Cushing, Thomas, F.R.A.S. India Store Depôt, Belvedere-road, Lambeth, London, S.W.

1889. §Dagger, John H., F.I.C., F.C.S. Endon, Staffordshire.
1854. ‡Daglish, Robert, M.Inst.C.E. Orrell Cottage, near Wigan.
1883. ‡Dähne, F. W., Consul of the German Empire. 18 Somerset-place, Swansea.
1889. *Dale, Miss Elizabeth. Girton College, Cambridge.
1887. ‡*Dale, Henry F., F.R.M.S., F.Z.S. Sutgrove, Miserden, Gloucestershire.*
1863. ‡Dale, J. B. South Shields.
1865. ‡Dale, Rev. R. W. 12 Calthorpe-street, Birmingham.
1867. ‡Dalgleish, W. Dundee.
1870. ‡DALLINGER, Rev. W. H., LL.D., F.R.S., F.L.S. Ingleside, Newstead-road, Lee, London, S.E.
Dalton, Edward, LL.D., F.S.A. Dunkirk House, Nailsworth.
1862. ‡DANBY, T. W., M.A., F.G.S. 1 Westbourne-terrace-road, London, W.
1859. ‡Dancer, J. B., F.R.A.S. Old Manor House, Ardwick, Manchester.
1876. ‡Dansken, John. 4 Eldon-terrace, Partickhill, Glasgow.
1849. *Danson, Joseph, F.C.S. Montreal, Canada.
1861. *DARBISHIRE, ROBERT DUKINFIELD, B.A., F.G.S. 26 George-street, Manchester.
1883. ‡Darbishire, S. D., M.D. 60 High-street, Oxford.
1876. ‡Darling, G. Erskine. 247 West George-street, Glasgow.
1884. ‡Darling, Thomas. 99 Drummond-street, Montreal, Canada.
1882. ‡DARWIN, FRANCIS, M.A., M.B., F.R.S., F.L.S. Huntingdon-road, Cambridge.
1881. *DARWIN, GEORGE HOWARD, M.A., LL.D., F.R.S., F.R.A.S., Plumian Professor of Astronomy and Experimental Philosophy in the University of Cambridge. Newnham Grange, Cambridge.
1878. *Darwin, Horace. The Orchard, Huntingdon-road, Cambridge.
1882. ‡Darwin, W. E., F.G.S. Bassett, Southampton.
1888. ‡Daubeny, William M. Stratton House, Park-lane, Bath.
1878. ‡*D'Aulmay, G. 22 Upper Leeson-street, Dublin.*
1872. ‡Davenport, John T. 64 Marine Parade, Brighton.
1880. §DAVEY, HENRY, M.Inst.C.E. 3 Prince's-street, Westminster, S.W.
1884. ‡David, A. J., B.A., LL.B. 4 Harcourt-buildings, Temple, London, E.C.
1870. ‡Davidson, Alexander, M.D. 2 Gambier-terrace, Liverpool.
1885. ‡Davidson, Charles B. Roundhay, Fonthill-road, Aberdeen.
1875. ‡Davies, David. 2 Queen's-square, Bristol.
1870. ‡Davies, Edward, F.C.S. Royal Institution, Liverpool.
1887. *Davies, H. Rees. Treborth, Bangor, North Wales.
1842. Davies-Colley, Dr. Thomas. Newton, near Chester.
1887. ‡Davies-Colley, T. C. Hopedene, Kersal, Manchester.
1873. *Davis, Alfred. 2 St. Ermin's Mansions, London, S.W
1870. *Davis, A. S. 6 Paragon-buildings, Cheltenham.
1864. ‡DAVIS, CHARLES E., F.S.A. 55 Pulteney-street, Bath
1887. §Davis, David. 55 Berkley-street, Liverpool.
Davis, Rev. David, B.A. Lancaster.

Year of Election.

1881. ‡*Davis, George E. The Willows, Fallowfield, Manchester.*
1882. §Davis, Henry C. Berry Pomeroy, Springfield-road, Brighton.
1873. *Davis, James W., F.G.S., F.S.A. Chevinedge, near Halifax.
1856. *Davis, Sir John Francis, Bart., K.C.B., D.C.L., F.R.S., F.R.G.S. Hollywood, near Compton, Bristol.
1883. ‡*Davis, Joseph, J.P. Park-road, Southport.*
1883. ‡Davis, Robert Frederick, M.A. Earlsfield, Wandsworth Common, London, S.W.
1885. **Davis, Rudolf. Castle Howell School, Lancaster.*
1886. ‡Davis, W. H. Hazeldean, Pershore-road, Birmingham.
1886. ‡Davison, Charles, M.A. 38 Charlotte-road, Birmingham.
1864. *Davison, Richard. Beverley-road, Great Driffield, Yorkshire.
1857. ‡Davy, Edmund W., M.D. Kimmage Lodge, Roundtown, near Dublin.
1869. ‡Daw, John. Mount Radford, Exeter.
1869. ‡Daw, R. R. M. Bedford-circus, Exeter.
1860. *Dawes, John T., F.G.S. Cefn Mawr Hall, Mold, North Wales.
1864. ‡Dawkins, W. Boyd, M.A., F.R.S., F.G.S., F.S.A., Professor of Geology and Palæontology in the Victoria University, Owens College, Manchester. Woodhurst, Fallowfield, Manchester.
1886. ‡Dawson, Bernard. The Laurels, Malvern Link.
1885. *Dawson, Major H. P., R.A. 3 Charlton Park-terrace, Old Charlton, Kent.
1884. ‡Dawson, Samuel. 258 University-street, Montreal, Canada.
1855. §Dawson, Sir William, C.M.G., M.A., LL.D., F.R.S., F.G.S., Principal of McGill University. McGill University, Montreal, Canada.
1859. *Dawson, Captain William G. Plumstead Common, Kent.
1871. ‡Day, St. John Vincent, M.Inst.C.E., F.R.S.E. 166 Buchanan-street, Glasgow.
1870. *Deacon, G. F., M.Inst.C.E. Municipal Offices, Liverpool.
1861. ‡Deacon, Henry. Appleton House, near Warrington.
1887. §Deakin, H. T. Egremont House, Belmont, near Bolton.
1861. ‡Dean, Henry. Colne, Lancashire.
1870. *Deane, Rev. George, B.A., D.Sc., F.G.S. 38 Wellington-road, Birmingham.
1884. *Debenham, Frank, F.S.S. 26 Upper Hamilton-terrace, London, N.W.
1866. ‡Debus, Heinrich, Ph.D., F.R.S., F.C.S., Lecturer on Chemistry at Guy's Hospital, London, S.E.
1884. §Deck, Arthur, F.C.S. 9 King's-parade, Cambridge.
1887. §Dehn, R. Olga Villa, Victoria Park, Manchester.
1878. ‡Delany, Rev. William. St. Stanislaus College, Tullamore.
1879. ‡De la Sala, Colonel. Sevilla House, Navarino-road, London, N.W.
1884. *De Laune, C. De L. F. Sharsted Court, Sittingbourne.
1887. ‡De Meschin, Miss Hannah Constance. Sandycove Castle, Kingstown, Ireland.
1870. ‡De Meschin, Thomas, B.A., LL.D. Sandycove Castle, Kingstown, Ireland.
1889. §Dendy, Frederick Walter. 3 Mardale-parade, Gateshead.
1873. ‡Denham, Thomas, J.P. Huddersfield.
1884. ‡Denman, Thomas W. Lamb's-buildings, Temple, London, E.C.
1889. §Denny, Alfred, F.L.S., Professor of Biology in the Firth College, Sheffield.
Dent, William Yerbury. Royal Arsenal, Woolwich.
1870. *Denton, J. Bailey. Orchard Court, Stevenage.
1874. §De Rance, Charles E., F.G.S. 28 Jermyn-street, London, S.W.

Year of Election.

1856. *DERBY, The Right Hon. the Earl of, K.G., M.A., LL.D., F.R.S., F.R.G.S. St. James's-square, London, S.W.; and Knowsley, near Liverpool.
1874. *Derham, Walter, M.A., LL.M., F.G.S. 119 Lansdowne-road, Kensington Park, London, W.
1878. ‡De Rinzy, James Harward. Khelat Survey, Sukkur, India.
1868. ‡Dessé, Etheldred, M.B., F.R.C.S. 43 Kensington Gardens-square, Bayswater, London, W.
DE TABLEY, Lord GEORGE, F.Z.S. Tabley House, Knutsford, Cheshire.
*DEVONSHIRE, His Grace the Duke of, K.G., M.A., LL.D., F.R.S., F.G.S., F.R.G.S., Chancellor of the University of Cambridge. Devonshire House, Piccadilly, London, W.; and Chatsworth, Derbyshire.
1868. ‡DEWAR, JAMES, M.A., F.R.S. L. & E., F.C.S., Fullerian Professor of Chemistry in the Royal Institution, London, and Jacksonian Professor of Natural and Experimental Philosophy in the University of Cambridge. 1 Scroope-terrace, Cambridge.
1881. ‡Dewar, Mrs. 1 Scroope-terrace, Cambridge.
1883. ‡Dewar, James, M.D., F.R.C.S.E. Drylaw House, Davidson's Mains, Midlothian, N.B.
1884. **Dewar, William. 6 Montpellier-grove, Cheltenham.*
1872. ‡Dewick, Rev. E. S., M.A., F.G.S. 26 Oxford-square, London, W.
1887. §DE WINTON, Colonel Sir F., K.C.M.G., C.B., D.C.L., Sec. R.G.S. 24 Tavistock-road, Westbourne Park, London, W.
1884. ‡De Wolf, O. C., M.D. Chicago, U.S.A.
1873. *DEW-SMITH, A. G., M.A. Trinity College, Cambridge.
1889. §Dickinson, A. H. Portland House, Newcastle-upon-Tyne.
1864. *Dickinson, F. H., F.G.S. Kingweston, Somerton, Taunton; and 121 St. George's-square, London, S.W.
1863. ‡Dickinson, G. T. Claremont-place, Newcastle-upon-Tyne.
1887. ‡Dickinson, Joseph, F.G.S. South Bank, Pendleton.
1884. ‡Dickson, Charles R., M.D. Wolfe Island, Ontario, Canada.
1881. ‡Dickson, Edmund. West Cliff, Preston.
1887. ‡Dickson, H. N. 38 York-place, Edinburgh.
1885. ‡Dickson, Patrick. Laurencekirk, Aberdeen.
1883. ‡Dickson, T. A. West Cliff, Preston.
1862. *DILKE, The Right Hon. Sir CHARLES WENTWORTH, Bart., F.R.G.S. 76 Sloane-street, London, S.W.
1877. ‡Dillon, James, M.Inst.C.E. 36 Dawson-street, Dublin.
1848. ‡DILLWYN, LEWIS LLEWELYN, M.P., F.L.S., F.G.S. Parkwerne, near Swansea.
1869. ‡Dingle, Edward. 19 King-street, Tavistock.
1889. §Dinning, William. 41 Eldon-street, Newcastle-upon-Tyne.
1876. ‡Ditchfield, Arthur. 12 Taviton-street, Gordon-square, London, W.C.
1868. ‡Dittmar, William, LL.D., F.R.S. L. & E., F.C.S., Professor of Chemistry in Anderson's College, Glasgow.
1884. ‡Dix, John William H. Bristol.
1874. *Dixon, A. E. Dunowen, Cliftonville, Belfast.
1883. ‡Dixon, Miss E. 2 Cliff-terrace, Kendal.
1888. §Dixon, E. T. Messrs. Lloyds, Barnetts, & Bosanquets' Bank, 54 St. James's-street, London, S.W.
1886. ‡Dixon, George. 42 Augustus-road, Edgbaston, Birmingham.
1879. *DIXON, HAROLD B., M.A., F.R.S., F.C.S., Professor of Chemistry in the Owens College, Manchester. Birch Hall, Rusholme, Manchester.
1885. ‡Dixon, John Henry. Inveran, Poolewe, Ross-shire, N.B.

Year of
Election.

1887. ‡Dixon, Thomas. Buttershaw, near Bradford, Yorkshire.
1885. ‡Doak, Rev. A. 15 Queen's-road, Aberdeen.
1885. §Dobbin, Leonard. The University, Edinburgh.
1860. *Dobbs, Archibald Edward, M.A. 34 Westbourne Park, London, W.
1878. *DOBSON, G. E., M.A., M.B., F.R.S., F.L.S. Adrigole, Spring Grove, Isleworth.
1864. *Dobson, William. Oakwood, Bathwick Hill, Bath.
1875. *Docwra, George, jun. 32 Union-street, Coventry.
1870. *Dodd, John. Nunthorpe-avenue, York.
1876. ‡Dodds, J. M. St. Peter's College, Cambridge.
1889. §Dodson, George, B.A. Downing College, Cambridge.
Dolphin, John. Delves House, Berry Edge, near Gateshead.
1887. *Donald, Provost Robert. City Chambers, Dunfermline, Scotland.
1885. ‡Donaldson, James, M.A., LL.D., F.R.S.E., Senior Principal of the University of St. Andrews, N.B.
1882. ‡Donaldson, John. Tower House, Chiswick, Middlesex.
1869. ‡Donisthorpe, G. T. St. David's Hill, Exeter.
1877. *Donkin, Bryan, jun. May's Hill, Shortlands, Kent.
1889. §Donkin, R. S., M.P. Campville, North Shields.
1861. ‡Donnelly, Col., R.E., C.B. South Kensington Museum, London, S.W.
1887. ‡Donner, Edward, B.A. 4 Anson-road, Victoria Park, Manchester.
1887. ‡Dorning, Elias, M.Inst.C.E., F.G.S. 41 John Dalton-street, Manchester.
1889. §Dorsey, E. B. International Club, Trafalgar-square, London, S.W.
1881. ‡Dorrington, John Edward. Lypiatt Park, Stroud.
1867. ‡Dougall, Andrew Maitland, R.N. Scotscraig, Tayport, Fifeshire.
1871. ‡*Dougall, John, M.D. 2 Cecil-place, Paisley-road, Glasgow.*
1863. *Doughty, Charles Montagu. Care of H. M. Doughty, Esq., 5 Stone-court, Lincoln's Inn, London, W.C.
1876. *Douglas, Rev. G. C. M. 18 Royal-crescent West, Glasgow.
1877. *DOUGLASS, Sir JAMES N., F.R.S., M.Inst.C.E. Trinity House, London, E.C.
1884. ‡Douglass, William Alexander. Freehold Loan and Savings Company, Church-street, Toronto, Canada.
1886. ‡Dovaston, John. West Felton, Shropshire.
1883. ‡Dove, Arthur. Crown Cottage, York.
1884. ‡Dove, Miss Frances. St. Leonard's, St. Andrews, N.B.
1884. ‡Dove, P. Edward, F.R.A.S., Sec.R.Hist.Soc. 23 Old-buildings, Lincoln's Inn, London, W.C.
1884. ‡Dowe, John Melnotte. 69 Seventh-avenue, New York, U.S.A.
1876. ‡Dowie, Mrs. Muir. Golland, by Kinross, N.B.
1884. *Dowling, D. J. Bromley, Kent.
1878. ‡Dowling, Thomas. Claireville House, Terenure, Dublin.
1857. ‡DOWNING, S., LL.D. 4 The Hill, Monkstown, Co. Dublin.
1878. ‡Dowse, The Right Hon. Baron. 38 Mountjoy-square, Dublin.
1865. *Dowson, E. Theodore, F.R.M.S. Geldeston, near Beccles, Suffolk.
1881. *Dowson, Joseph Emerson, M.Inst.C.E. 3 Great Queen-street, London, S.W.
1887. §Doxey, R. A. Slade House, Levenshulme, Manchester.
1883. ‡Draper, William. De Grey House, St. Leonard's, York.
1868. ‡DRESSER, HENRY E., F.Z.S. 6 Tenterden-street, Hanover-square, London, W.
1873. §DREW, FREDERIC, F.G.S., F.R.G.S. Eton College, Windsor.
1879. ‡Drew, Samuel, M.D., D.Sc., F.R.S.E. 10 Laura-place, Bath.
1887. ‡Dreyfus, Dr. Daisy Mount, Victoria Park, Manchester.
1889. §Drummond, Dr. 6 Saville-place, Newcastle-upon-Tyne.
1870. ‡Drysdale, J. J., M.D. 36A Rodney-street, Liverpool.

Year of Election.

1889. §Du Chaillu, Paul B. Care of John Murray, Esq., 50A Albemarle-street, London, W.
1856. *DUCIE, The Right. Hon. HENRY JOHN REYNOLDS MORETON, Earl of, F.R.S., F.G.S. 16 Portman-square, London, W.; and Tortworth Court, Wotton-under-Edge.
1870. ‡Duckworth, Henry, F.L.S., F.G.S. Holme House, Columbia-road, Oxton, Birkenhead.
1867. *DUFF, The Right Hon. Sir MOUNTSTUART ELPHINSTONE GRANT-, G.C.S.I., F.R.S., F.R.G.S. York House, Twickenham.
1852. ‡Dufferin and Ava, The Most Hon. the Marquis of, K.P., G.C.B., G.C.M.G., G.C.S.I., D.C.L., LL.D., F.R.S., F.R.G.S. Clandeboye, near Belfast, Ireland.
1877. ‡Duffey, George F., M.D. 30 Fitzwilliam-place, Dublin.
1875. ‡Duffin, W. E. L'Estrange. Waterford.
1884. §Dugdale, James H. 9 Hyde Park-gardens, London, W.
1883. §Duke, Frederic. Conservative Club, Hastings.
1859. *Duncan, Alexander. 7 Prince's-gate, London, S.W.
1866. *Duncan, James. 9 Mincing-lane, London, E.C.
Duncan, J. F., M.D. 8 Upper Merrion-street, Dublin.
1867. ‡DUNCAN, PETER MARTIN, M.B., F.R.S., F.G.S., Professor of Geology in King's College, London. 6 Grosvenor-road, Gunnersbury, London, W.
1880. ‡Duncan, William S. 22 Delamere-terrace, Bayswater, London, W.
1881. ‡Duncombe, The Hon. Cecil. Nawton Grange, York.
1881. ‡Dunhill, Charles H. Gray's-court, York.
1865. ‡Dunn, David. Annet House, Skelmorlie, by Greenock, N.B.
1882. §Dunn, J. T., M.Sc., F.C.S. High School for Boys, Gateshead-on-Tyne.
1883. ‡Dunn, Mrs. Denton Grange, Gateshead-on-Tyne.
1876. ‡Dunnachie, James. 2 West Regent-street, Glasgow.
1878. ‡Dunne, D. B., M.A., Ph.D., Professor of Logic in the Catholic University of Ireland. 4 Clanwilliam-place, Dublin.
1884. §Dunnington, F. P. University of Virginia, Albemarle Co., Virginia, U.S.A.
1859. ‡Duns, Rev. John, D.D., F.R.S.E. New College, Edinburgh.
1885. *DUNSTAN, WYNDHAM R., M.A., F.C.S., Professor of Chemistry to the Pharmaceutical Society of Great Britain. 17 Bloomsbury-square, London, W.C.
1866. ‡Duprey, Perry. Woodberry Down, Stoke Newington, London, N.
1869. ‡D'Urban, W. S. M., F.L.S. 4 Queen-terrace, Mount Radford, Exeter.
1860. ‡DURHAM, ARTHUR EDWARD, F.R.C.S., F.L.S., Demonstrator of Anatomy, Guy's Hospital. 82 Brook-street, Grosvenor-square, London, W.
1887. ‡Durham, William. Seaforth House, Portobello, Scotland.
1887. ‡Dyason, John Sanford, F.R.G.S., F.R.Met.Soc. Boscobel-gardens, London, N.W.
1884. ‡Dyck, Professor Walter. The University, Munich.
1885. *Dyer, Henry, M.A. 8 Highburgh-terrace, Dowanhill, Glasgow.
Dykes, Robert. Kilmorie, Torquay, Devon.
1869. *Dymond, Edward E. Oaklands, Aspley Guise, Woburn.

1868. ‡Eade, Peter, M.D. Upper St. Giles's-street, Norwich.
1861. ‡*Eadson, Richard. 13 Hyde-road, Manchester.*
1883. ‡Eagar, Rev. Thomas. The Rectory, Ashton-under-Lyne.
1877. ‡Earle, Ven. Archdeacon, M.A. West Alvington, Devon.
1888. ‡Earson, H. W. P. 11 Alexandra-road, Clifton, Bristol.

Year of Election.

1874. ‡Eason, Charles. 30 Kenilworth-square, Rathgar, Dublin.
1871. *EASTON, EDWARD, M.Inst.C.E., F.G.S. 11 Delahay-street, Westminster, S.W.
1863. ‡Easton, James. Nest House, near Gateshead, Durham.
1876. ‡Easton, John. Durie House, Abercromby-street, Helensburgh, N.B.
1883. ‡Eastwood, Miss. Littleover Grange, Derby.
1887. §Eccles, Mrs. S. White Coppice, Chorley, Lancashire.
1884. ‡Eckersley, W. T. Standish Hall, Wigan, Lancashire.
1861. ‡Ecroyd, William Farrer. Spring Cottage, near Burnley.
1858. *Eddison, Francis. Syward Lodge, Dorchester.
1870. *Eddison, John Edwin, M.D., M.R.C.S. 29 Park-square, Leeds.
*Eddy, James Ray, F.G.S. The Grange, Carleton, Skipton.
1887. §Ede, Francis J. Silchar, Cachar, India.
Eden, Thomas. Talbot-road, Oxton.
1884. *Edgell, R. Arnold, M.A., F.C.S. 58 Abingdon-villas, Kensington, London, W.
1887. §EDGEWORTH, F. Y., M.A., D.C.L., F.S.S., Professor of Political Economy in King's College, London. Athenæum Club, Pall Mall, London, S.W.
1870. *Edmonds, F. B. 72 Portsdown-road, London, W.
1883. ‡Edmonds, William. Wiscombe Park, Honiton, Devon.
1888. *Edmunds, Henry. Rhodehurst, Streatham, London, S.W.
1884. *Edmunds, James, M.D. 8 Grafton-street, Piccadilly, London, W.
1883. ‡Edmunds, Lewis, D.Sc., LL.B. 60 Park-street, Park-lane, London, W.
1867. *Edward, Allan. Farington Hall, Dundee.
1867. ‡*Edward, Charles. Chambers, 8 Bank-street, Dundee.*
1855. *EDWARDS, Professor J. BAKER, Ph.D., D.C.L. Montreal, Canada.
1884. ‡Edwards, W. F. Niles, Michigan, U.S.A.
1887. *Egerton of Tatton, The Right Hon. Lord. Tatton Park, Knutsford.
1876. ‡Elder, Mrs. 6 Claremont-terrace, Glasgow.
1885. *Elgar, Francis, LL.D., F.R.S.E., Director of H.M. Dockyards. The Admiralty, London, S.W.
1868. ‡Elger, Thomas Gwyn Empy, F.R.A.S. Manor Cottage, Kempston, Bedford.
1863. ‡Ellenberger, J. L. Worksop.
1885. §Ellingham, Frank. Thorpe St. Andrew, Norwich.
1883. ‡Ellington, Edward Bayzand, M.Inst.C.E. Palace-chambers, Bridge-street, Westminster, S.W.
1864. ‡Elliott, E. B. Washington, U.S.A.
1883. *ELLIOTT, EDWIN BAILEY, M.A. Queen's College, Oxford.
1872. ‡*Elliott, Rev. E. B. 11 Sussex-square, Kemp Town, Brighton.*
Elliott, John Fogg. Elvet Hill, Durham.
1879. ‡Elliott, Joseph W. Post Office, Bury, Lancashire.
1886. §Elliott, Thomas Henry, F.S.S. Local Government Board, Whitehall, London, S.W.
1864. *ELLIS, ALEXANDER JOHN, B.A., F.R.S., F.S.A. 21 Auriol-road, West Kensington, London, W.
1877. ‡Ellis, Arthur Devonshire. School of Mines, Jermyn-street, London, S.W.; and Thurnscoe Hall, Rotherham, Yorkshire.
1875. *Ellis, H. D. 6 Westbourne-terrace, Hyde Park, London, W.
1883. ‡Ellis, John. 17 Church-street, Southport.
1880. *ELLIS, JOHN HENRY. New Close, Cambridge-road, Southport.
1864. *Ellis, Joseph. Hampton Lodge, Brighton.
1864. ‡*Ellis, J. Walter. High House, Thornwaite, Ripley, Yorkshire.*

Year of Election.

1884. ‡Ellis, W. Hodgson. Toronto, Canada.
1869. ‡ELLIS, WILLIAM HORTON. Hartwell House, Exeter.
Ellman, Rev. E. B. Berwick Rectory, near Lewes, Sussex.
1887. †Elmy, Ben. Eaton Hall, Congleton, Manchester.
1862. ‡Elphinstone, H. W., M.A., F.L.S. 2 Stone-buildings, Lincoln's Inn, London, W.C.
1883. ‡Elwes, George Robert. Bossington, Bournemouth.
1887. §Elworthy, Frederick T. Foxdown, Wellington, Somerset.
1870. *ELY, The Right Rev. Lord ALWYNE COMPTON, D.D., Lord Bishop of. The Palace, Ely, Cambridgeshire.
1863. ‡Embleton, Dennis, M.D. 19 Claremont-place, Newcastle-upon-Tyne.
1884. ‡Emery, Albert H. Stamford, Connecticut, U.S.A.
1863. ‡Emery, The Ven. Archdeacon, B.D. Ely, Cambridgeshire.
1886. ‡*Emmons, Hamilton. Mount Vernon Lodge, Leamington.*
1858. ‡Empson, Christopher. Bramhope Hall, Leeds.
1866. ‡Enfield, Richard. Low Pavement, Nottingham.
1884. ‡England, Luther M. Knowlton, Quebec, Canada.
1853. ‡English, Edgar Wilkins. Yorkshire Banking Company, Lowgate, Hull.
1869. ‡English, J. T. Wayfield House, Stratford-on-Avon.
1883. ‡Entwistle, James P. Beachfield, 2 Westclyffe-road, Southport.
1869. *Enys, John Davis. Care of F. G. Enys, Esq., Enys, Penryn, Cornwall.
1844. ‡Erichsen, John Eric, LL.D., F.R.S., F.R.C.S., President of, and Emeritus Professor of Surgery in, University College, London. 6 Cavendish-place, London, W.
1864. *Eskrigge, R. A., F.G.S. 18 Hackins-hey, Liverpool.
1885. ‡Esselmont, Peter, M.P. 34 Albyn-place, Aberdeen.
1862. *ESSON, WILLIAM, M.A., F.R.S., F.C.S., F.R.A.S. Merton College, and 13 Bradmore-road, Oxford.
1878. ‡Estcourt, Charles, F.C.S. 8 St. James's-square, John Dalton-street, Manchester.
1887. *Estcourt, Charles. Vyrnieu House, Talbot-road, Old Trafford, Manchester.
1887. *Estcourt, P. A. Vyrnieu House, Talbot-road, Old Trafford, Manchester.
Estcourt, Rev. W. J. B. Long Newton, Tetbury.
1869. ‡ETHERIDGE, ROBERT, F.R.S. L. & E., F.G.S., Assistant Keeper (Geological and Palæontological Department) Natural History Museum (British Museum). 14 Carlyle-square, London, S.W.
1888. §Etheridge, Mrs. 14 Carlyle-square, London, S.W.
1883. §Eunson, Henry J. Morvi, Kathiawar, Bombay Presidency.
1881. ‡*Evans, Alfred. Exeter College, Oxford.*
1889. *Evans, A. H. 9 Harvey-road, Cambridge.
1887. *Evans, Mrs. Alfred W. A. Hillside, New Mills, near Stockport, Derbyshire.
1870. *Evans, Arthur John, F.S.A. 33 Holywell, Oxford.
1865. *EVANS, Rev. CHARLES, M.A. The Rectory, Solihull, Birmingham.
1889. §Evans, Henry Jones. Greenhill, Whitchurch, Cardiff.
1884. ‡Evans, Horace L. Moreton House, Tyndall's Park, Bristol.
1869. *Evans, H. Saville W. Wimbledon Park House, Wimbledon, Surrey.
1861. *EVANS, JOHN, D.C.L., LL.D., Treas.R.S., F.S.A., F.L.S., F.G.S. Nash Mills, Hemel Hempstead.
1883. *Evans, J. C. Albany-buildings, Lord-street, Southport.
1883. *Evans, Mrs. J. C. Albany-buildings, Lord-street, Southport.
1881. ‡Evans, Lewis. Llanfyrnach R.S.O., Pembrokeshire.

Year of Election.

1876. ‡*Evans, Mortimer, M.Inst. C.E. 97 West Regent-street, Glasgow.*
1885. *Evans, Percy Bagnall. The Spring, Kenilworth.
1865. ‡*Evans, Sebastian, M.A., LL.D. Heathfield, Alleyne Park, Lower Norwood, Surrey, S.E.*
1875. ‡Evans, Sparke. 3 Apsley-road, Clifton, Bristol.
1865. *Evans, William. The Spring, Kenilworth.
1886. ‡Eve, A. S. Marlborough College, Wilts.
1871. ‡Eve, H. Weston, M.A. University College, London, W.C.
1868. *EVERETT, J. D., M.A., D.C.L., F.R.S. L. & E., Professor of Natural Philosophy in Queen's College, Belfast. 5 Princess-gardens, Belfast.
1863. *Everitt, George Allen, F.R.G.S. Knowle Hall, Warwickshire.
1886. ‡Everitt, William E. Finstall Park, Bromsgrove.
1883. ‡Eves, Miss Florence. Uxbridge.
1881. ‡EWART, J. COSSAR, M.D., Professor of Natural History in the University of Edinburgh.
1874. ‡Ewart, Sir W. Quartus, Bart. Glenmachan, Belfast.
1859. *Ewing, Sir Archibald Orr, Bart., M.P. Ballikinrain Castle, Killearn, Stirlingshire.
1876. *EWING, JAMES ALFRED, B.Sc., F.R.S. L. & E., Professor of Engineering in University College, Dundee.
1883. ‡Ewing, James L. 52 North Bridge, Edinburgh.
1871. *Exley, John T., M.A. 1 Cotham-road, Bristol.
1884. *Eyerman, John. Easton, Pennsylvania, U.S.A.
1882. ‡Eyre, G. E. Briscoe. Warrens, near Lyndhurst, Hants.
Eyton, Charles. Hendred House, Abingdon.

1884. ‡Fairbairn, Dr. A. M. Airedale College, Bradford, Yorkshire.
1865. *FAIRLEY, THOMAS, F.R.S.E., F.C.S. 8 Newton-grove, Leeds.
1876. ‡*Fairlie, James M. Charing Cross Corner, Glasgow.*
1870. ‡*Fairlie, Robert. Woodlands, Clapham Common, London, S.W.*
1886. ‡Fairley, William. Beau Desert, Rugeley, Staffordshire.
1864. ‡Falkner, F. H. Lyncombe, Bath.
1886. ‡Fallon, T. P., Consul General. Australia.
1883. ‡Fallon, Rev. W. S. 1 St. Alban's-terrace, Cheltenham.
1877. §FARADAY, F. J., F.L.S., F.S.S. College-chambers, 17 Brazenose-street, Manchester.
1887. ‡Farmer, Sir James. Hope House, Eccles Old-road, Manchester.
1886. §Farncombe, Joseph, J.P. Lewes.
1879. *Farnworth, Ernest. Clarence Villa, Penn Fields, Wolverhampton.
1883. §Farnworth, Walter. 86 Preston New-road, Blackburn.
1883. ‡Farnworth, William. 86 Preston New-road, Blackburn.
1885. ‡Farquhar, Admiral. Carlogie, Aberdeen.
1859. ‡Farquharson, Robert F. O. Haughton, Aberdeen.
1885. ‡Farquharson, Mrs. R. F. O. Haughton, Aberdeen.
1866. *FARRAR, Ven. FREDERIC WILLIAM, M.A., D.D., F.R.S., Archdeacon of Westminster. St. Margaret's Rectory, Westminster, S.W.
1883. ‡Farrell, John Arthur. Moynalty, Kells, North Ireland.
1857. ‡Farrelly Rev. Thomas. Royal College, Maynooth.
1869. *Faulding, Joseph. Ebor Villa, Godwin-road, Clive-vale, Hastings.
1883. §Faulding, Mrs. Ebor Villa, Godwin-road, Cive-vale, Hastings.
1887. §Faulkner, John. 13 Great Ducie-street, Strangeways, Manchester.
1886. §Felkin, Robert W., M.D., F.R.G.S. 20 Alva-street, Edinburgh.
Fell, John B. Spark's Bridge, Ulverstone, Lancashire.
1864. *FELLOWS, FRANK P., K.S.J.J., F.S.A., F.S.S. 8 The Green, Hampstead, London, N.W.

Year of Election.

1852. ‡Fenton, S. Greame. 9 College-square; and Keswick, near Belfast.
1883. ‡Fenwick, E. H. 29 Harley-street, London, W.
1876. ‡Ferguson, Alexander A. 11 Grosvenor-terrace, Glasgow.
1883. ‡Ferguson, Mrs. A. A. 11 Grosvenor-terrace, Glasgow.
1859. ‡*Ferguson, John. Cove, Nigg, Inverness.*
1871. *Ferguson, John, M.A., Professor of Chemistry in the University of Glasgow.
1867. ‡Ferguson, Robert M., Ph.D., F.R.S.E. 8 Queen-street, Edinburgh.
1854. ‡Ferguson, William, F.L.S., F.G.S. Kinmundy, near Mintlaw, Aberdeenshire.
1867. *Fergusson, H. B. 13 Airlie-place, Dundee.
1883. ‡Fernald, H. P. Alma House, Cheltenham.
1883. *Fernie John. Box No. 2, Hutchinson, Kansas, U.S.A.
1862. ‡FERRERS, Rev. NORMAN MACLEOD, D.D., F.R.S. Caius College Lodge, Cambridge.
1873. ‡Ferrier, David, M.A., M.D., LL.D., F.R.S., Professor of Neuro-Pathology in King's College. 34 Cavendish-square, London, W.
1882. §Fewings, James, B.A., B.Sc. The Grammar School, Southampton.
1887. ‡Fiddes, Thomas, M.D. Penwood, Urmston, near Manchester.
1875. ‡Fiddes, Walter. Clapton Villa, Tyndall's Park, Clifton, Bristol.
1868. ‡Field, Edward. Norwich.
1886. ‡Field, H. C. 4 Carpenter-road, Edgbaston, Birmingham.
1869. *FIELD, ROGERS, B.A., M.Inst.C.E. 4 Westminster-chambers, Westminster, S.W.
1887. ‡Fielden, John C. 145 Upper Brook-street, Manchester.
1882. ‡Filliter, Freeland. St. Martin's House, Wareham, Dorset.
1883. *Finch, Gerard B., M.A. 1 St. Peter's-terrace, Cambridge.
Finch, John. Bridge Work, Chepstow.
1885. ‡FINDLATER, JOHN. 60 Union-street, Aberdeen.
1878. *Findlater, William. 22 Fitzwilliam-square, Dublin.
1885. ‡Findlay, George, M.A. 50 Victoria-street, Aberdeen.
1884. ‡Finlay, Samuel. Montreal, Canada.
1887. ‡Finnemore, Rev. J., F.G.S. Aston-road, Birmingham.
1881. ‡Firth, Colonel Sir Charles. Heckmondwike.
Firth, Thomas. Northwich.
1863. *Firth, William. Burley Wood, near Leeds.
1858. ‡Fishbourne, Admiral E. G., R.N. 26 Hogarth-road, Earl's Court-road, London, S.W.
1884. *Fisher, L. C. Galveston, Texas, U.S.A.
1869. ‡FISHER, Rev. OSMOND, M.A., F.G.S. Harlton Rectory, near Cambridge.
1873. ‡Fisher, William. Maes Fron, near Welshpool, Montgomeryshire.
1879. ‡Fisher, William. Norton Grange, near Sheffield.
1875. *Fisher, W. W., M.A., F.C.S. 5 St. Margaret's-road, Oxford.
1858. ‡Fishwick, Henry. Carr-hill, Rochdale.
1887. *Fison, Alfred H., D.Sc. University College, London, W.C.
1885. ‡Fison, E. Herbert. Stoke House, Ipswich.
1871. *FISON, FREDERICK W., M.A., F.C.S. Eastmoor, Ilkley, Yorkshire.
1871. ‡FITCH, J. G., M.A., LL.D. 5 Lancaster-terrace, Regent's Park, London, N.W.
1883. ‡Fitch, Rev. J. J. Ivyholme, Southport.
1868. ‡Fitch, Robert, F.G.S., F.S.A. Norwich.
1878. ‡Fitzgerald, C. E., M.D. 27 Upper Merrion-street, Dublin.
1878. §FITZGERALD, GEORGE FRANCIS, M.A., F.R.S., Professor of Natural and Experimental Philosophy, Trinity College, Dublin.
1885. *Fitzgerald, Professor Maurice, B.A. 37 Botanic-avenue, Belfast.
1857. ‡Fitzpatrick, Thomas, M.D. 31 Lower Baggot-street, Dublin.

Year of Election.

1888. *Fitzpatrick, Thomas C. Christ's College, Cambridge.
1865. ‡Fleetwood, D. J. 45 George-street, St. Paul's, Birmingham.
1881. ‡Fleming, Rev. Canon James, B.D. The Residence, York.
1876. ‡Fleming, James Brown. Beaconsfield, Kelvinside, near Glasgow.
1876. ‡Fleming, Sandford. Ottawa, Canada.
1867. §Fletcher, Alfred E., F.C.S. 57 Gordon-square, London, W.C.
1870. ‡Fletcher, B. Edgington. Norwich.
1886. ‡Fletcher, Frank M. 57 Gordon-square, London, W.C.
1869. ‡Fletcher, Lavington E., M.Inst.C.E. Alderley Edge, Cheshire.
1888. *Fletcher, Lazarus, M.A., F.R.S., F.G.S., F.C.S., Keeper of Minerals, British Museum (Natural History). Cromwell-road, London, S.W.
1862. §Flower, William Henry, C.B., LL.D., D.C.L., F.R.S., F.L.S., F.G.S., F.R.C.S., Director of the Natural History Departments, British Museum, South Kensington, London. (President.) 26 Stanhope-gardens, London, S.W.
1889. §Flower, Mrs. 26 Stanhope-gardens, London, S.W.
1877. *Floyer, Ernest A., F.R.G.S., F.L.S. Helwan, Egypt.
1887. ‡Foale, William. 3 Meadfoot-terrace, Mannamead, Plymouth.
1883. ‡Foale, Mrs. William. 3 Meadfoot-terrace, Mannamead, Plymouth.
1881. ‡Foljambe, Cecil G. S., M.P. 2 Carlton House-terrace, Pall Mall, London, S.W.
1879. ‡Foote, Charles Newth, M.D. 3 Albion-place, Sunderland.
1880. ‡Foote, R. Bruce. Care of Messrs. H. S. King & Co., 65 Cornhill, London, E.C.
1873. *Forbes, George, M.A., F.R.S. L. & E. 34 Great George-street, London, S.W.
1883. ‡Forbes, Henry O., F.Z.S., Director of the Canterbury Museum, Christchurch, New Zealand.
1885. ‡Forbes, The Right Hon. Lord. Castle Forbes, Aberdeenshire.
1866. ‡*Ford, William. Hartsdown Villa, Kensington Park-gardens East, London, W.*
1875. *Fordham, H. George, F.G.S. Rue de Martheray, 6, Lausanne, Switzerland.
1883. §Formby, R. Formby, near Liverpool.
1887. ‡Forrest, John, C.M.G., F.R.G.S. Perth, Western Australia.
1867. ‡Forster, Anthony. Finlay House, St. Leonards-on-Sea.
1883. ‡Forsyth, A. R., M.A., F.R.S. Trinity College, Cambridge.
1884. ‡Fort, George H. Lakefield, Ontario, Canada.
1877. ‡Fortescue, The Right Hon. the Earl. Castle Hill, North Devon.
1882. §Forward, Henry. 2 St. Agnes-terrace, Victoria Park-road, London, E.
1870. ‡Forwood, Sir William B. Hopeton House, Seaforth, Liverpool.
1875. ‡Foster, A. Le Neve. 51 Cadogan-square, London, S.W.
1865. ‡Foster, Balthazar, M.D., Professor of Medicine in Queen's College, Birmingham. 16 Temple-row, Birmingham.
1865. *Foster, Clement Le Neve, B.A., D.Sc., F.G.S. Llandudno.
1883. ‡Foster, Mrs. C. Le Neve. Llandudno.
1857. *Foster, George Carey, B.A., F.R.S., F.C.S., Professor of Physics in University College, London. 18 Daleham-gardens, Hampstead, London, N.W.
1877. §Foster, Joseph B. 6 James-street, Plymouth.
1859. *Foster, Michael, M.A., M.D., LL.D., Sec. R.S., F.L.S., F.C.S., Professor of Physiology in the University of Cambridge. Trinity College, and Great Shelford, near Cambridge.
1863. ‡Foster, Robert. 30 Rye-hill, Newcastle-upon-Tyne.
1866. ‡Fowler, George, M.Inst.C.E., F.G.S. Basford Hall, near Nottingham.

Year of Election.

1868. ‡Fowler, G. G. Gunton Hall, Lowestoft, Suffolk.
1888. §Fowler, Gilbert J. Dalton Hall, Manchester.
1876. *Fowler, John. 4 Kelvin Bank-terrace, Sandyford, Glasgow.
1882. ‡Fowler, Sir John, K.C.M.G., M.Inst.C.E., F.G.S. 2 Queen Square-place, Westminster, S.W.
1870. *Fowler, Sir Robert Nicholas, Bart., M.A., M.P., F.R.G.S. 137 Harley-street, London, W.
1884. ‡Fox, Miss A. M. Penjerrick, Falmouth.
1883. *Fox, Charles. The Cedars, Warlingham, Surrey.
1883. §Fox, Sir Charles Douglas, M.Inst.C.E. 5 Delahay-street, Westminster, S.W.
1860. *Fox, Rev. Edward, M.A. Silverdale, Hassocks, Sussex.
1883. ‡Fox, Howard, F.G.S. Falmouth.
1847. *Fox, Joseph Hoyland. The Cleve, Wellington, Somerset.
1860. ‡*Fox, Joseph John. Lordship-terrace, Stoke Newington, London, N.*
1876. ‡*Fox, St. G. Lane. 9 Sussex-place, London, S.W.*
1888. §Fox, Thomas. Court, Wellington, Somerset.
1886. ‡Foxwell, Arthur, M.A., M.B. 17 Temple-row, Birmingham.
1881. *Foxwell, Herbert S., M.A., F.S.S., Professor of Political Economy in University College, London. St. John's College, Cambridge.
1889. §Frain, Joseph, M.D. Grosvenor-place, Jesmond, Newcastle-upon-Tyne.
1866. *Francis, G. B. Vale House, Hertford.
1884. ‡Francis, James B. Lowell, Massachusetts, U.S.A.
Francis, William, Ph.D., F.L.S., F.G.S., F.R.A.S. Red Lion-court, Fleet-street, London, E.C.; and Manor House, Richmond, Surrey.
1846. ‡Frankland, Edward, M.D., D.C.L., LL.D., Ph.D., F.R.S., F.C.S. The Yews, Reigate Hill, Surrey.
1887. *Frankland, Percy F., Ph.D., B.Sc., Professor of Chemistry in University College, Dundee.
1889. §Franklin, Rev. Canon. Clayton-street West, Newcastle-upon-Tyne.
1882. §Fraser, Alexander, M.B. Royal College of Surgeons, Dublin.
1885. ‡Fraser, Angus, M.A., M.D., F.C.S. 232 Union-street, Aberdeen.
1859. ‡Fraser, George B. 3 Airlie-place, Dundee.
Fraser, James William. 8a Kensington Palace-gardens, London, W.
1865. *Fraser, John, M.A., M.D. Chapel Ash, Wolverhampton.
1871. ‡Fraser, Thomas R., M.D., F.R.S. L. & E., Professor of Materia Medica and Clinical Medicine in the University of Edinburgh. 13 Drumsheugh-gardens, Edinburgh.
1859. *Frazer, Daniel. 127 Buchanan-street, Glasgow.
1871. ‡Frazer, Evan L. R. Brunswick-terrace, Spring Bank, Hull.
1884. *Frazer, Persifor, M.A., D.Sc., Professor of Chemistry in the Franklin Institute of Pennsylvania. Room 1042, Drexel Buildings, Fifth and Chestnut-streets, Philadelphia, U.S.A.
1884. *Fream, W., LL.D., B.Sc., F.L.S., F.G.S., F.S.S., Professor of Natural History in the College of Agriculture, Downton, Salisbury.
1860. ‡Freeborn, Richard Fernandez. 38 Broad-street, Oxford.
1847. *Freeland, Humphrey William, F.G.S. West-street, Chichester.
1877. §Freeman, Francis Ford. 8 Leigham-terrace, Plymouth.
1865. ‡Freeman, James. 15 Francis-road, Edgbaston, Birmingham.
1841. Freeth, Major-General S. 30 Royal-crescent, Notting Hill, London, W.
1884. *Fremantle, The Hon. Sir C. W., K.C.B. Royal Mint, London, E.
1869. ‡Frere, Rev. William Edward. The Rectory, Bitton, near Bristol.
1886. ‡Freshfield, Douglas W., Sec.R.G.S. 1 Savile-row, London, W.

Year of Election.

1886. ‡Freund, Miss Ida. Eyre Cottage, Upper Sydenham, S.E.
1887. ‡Fries, Harold H., Ph.D. 92 Reade-street, New York, U.S.A.
1857. **Frith, Richard Hastings, M.R.I.A., F.R.G.S.I.* 48 *Summer-hill, Dublin.*
1887. §Froehlich, The Chevalier. Grosvenor-terrace, Withington, Manchester.
1882. §Frost, Edward P., J.P. West Wratting Hall, Cambridgeshire.
1883. ‡Frost, Major H., J.P. West Wratting Hall, Cambridgeshire.
1887. *Frost, Robert, B.Sc. St. James's-chambers, Duke-street, London, S.W.
1875. ‡Fry, F. J. 104 Pembroke-road, Clifton, Bristol.
1875. *Fry, Joseph Storrs. 2 Charlotte-street, Bristol.
1884. §Fryer, Joseph, J.P. Smelt House, Howden-le-Wear, Co. Durham.
1872. *Fuller, Rev. A. Pallant, Chichester.
1859. ‡Fuller, Frederick, M.A. 9 Palace-road, Surbiton.
1869. ‡Fuller, George, M.Inst.C.E. 71 Lexham-gardens, Kensington, London, W.
1884. §Fuller, William. Oswestry.

1881. ‡Gabb, Rev. James, M.A. Bulmer Rectory, Welburn, Yorkshire.
1887. ‡Gaddum, G. H. Adria House, Toy-lane, Withington, Manchester
*Gadesden, Augustus William, F.S.A. Ewell Castle, Surrey.
1857. ‡Gages, Alphonse, M.R.I.A. Museum of Irish Industry, Dublin.
1876. ‡Gairdner, Charles. Broom, Newton Mearns, Renfrewshire.
1850. ‡Gairdner, Professor W. T., M.D. 225 St. Vincent-street, Glasgow.
Galbraith, Rev. J. A., M.A., M.R.I.A. Trinity College, Dublin.
1876. ‡Gale, James M. 23 Miller-street, Glasgow.
1863. ‡Gale, Samuel, F.C.S. 225 Oxford-street, London, W.
1885. *Gallaway, Alexander. Dirgarve, Aberfeldy, N.B.
1888. ‡Gallenga, Mrs. Anna. The Falls, Chepstow.
1888. ‡Gallenga, Mrs. A. A. R. The Falls, Chepstow.
1861. ‡Galloway, Charles John. Knott Mill Iron Works, Manchester.
1861. ‡Galloway, John, jun. Knott Mill Iron Works, Manchester.
1889. §Galloway, Walter. Eighton Banks, Gateshead.
1875. ‡Galloway, W. Cardiff.
1887. *Galloway, W. The Cottage, Seymour-grove, Old Trafford, Manchester.
1860. *Galton, Sir Douglas, K.C.B., D.C.L., LL.D., F.R.S., F.L.S., F.G.S., F.R.G.S. (General Secretary.) 12 Chester-street, Grosvenor-place, London, S.W.
1860. *Galton, Francis, M.A., F.R.S., F.G.S., F.R.G.S. 42 Rutland-gate, Knightsbridge, London, S.W.
1869. ‡Galton, John C., M.A., F.L.S. 40 Great Marlborough-street, London, W.
1887. *Galton, Miss Laura Gwendolen Douglas. 12 Chester-street, Grosvenor-place, London, S.W.
1870. §Gamble, Lieut.-Colonel D. St. Helens, Lancashire.
1889. §Gamble, David, jun. St. Helens, Lancashire.
1870. ‡Gamble, J. C. St. Helens, Lancashire.
1872. *Gamble, John G., M.A. Athenæum Club, London, S.W.
1888. §Gamble, J. Sykes, M.A., F.L.S. Adyar, Madras.
1877. ‡Gamble, William. St. Helens, Lancashire.
1868. ‡Gamgee, Arthur, M.D., F.R.S. 17 Great Cumberland-place, London, W.
1889. §Gamgee, John. 6 Lingfield-road, Wimbledon, Surrey.
1883. ‡Gant, Major John Castle. St. Leonards.
1887. §Gardiner Walter, M.A. Clare College, Cambridge.
1882. *Gardner, H. Dent, F.R.G.S. 25 Northbrook-road, Lee, Kent.

Year of Election.

1882. ‡GARDNER, JOHN STARKIE, F.G.S. 7 Damer-terrace, Chelsea, London, S.W.
1884. ‡Garman, Samuel. Cambridge, Massachusetts, U.S.A.
1862. ‡GARNER, ROBERT, F.L.S. Stoke-upon-Trent.
1865. ‡Garner, Mrs. Robert. Stoke-upon-Trent.
1888. §Garnett, Frederick Brooksbank, C.B. 4 Argyll-road, Campden Hill, London, W.
1887. *Garnett, Jeremiah. The Grange, near Bolton, Lancashire.
1882. ‡Garnett, William, D.C.L., Principal of the College of Physical Science, Newcastle-on-Tyne.
1873. ‡Garnham, John. Hazelwood, Crescent-road, St. John's, Brockley, Kent, S.E.
1883. §Garson, J. G., M.D. 14 Suffolk-street, Pall Mall, London, S.W.
1874. *Garstin, John Ribton, M.A., LL.B., M.R.I.A., F.S.A. Bragans-town, Castlebellingham, Ireland.
1882. ‡Garton, William. Woolston, Southampton.
1889. §Garwood, E. J. 14 St. Mary's-place, Newcastle-upon-Tyne.
1870. ‡Gaskell, Holbrook. Woolton Wood, Liverpool.
1870. *Gaskell, Holbrook, jun. Clayton Lodge, Aigburth, Liverpool.
1862. *Gatty, Charles Henry, M.A., F.L.S., F.G.S. Felbridge Place, East Grinstead, Sussex.
1875. ‡Gavey, J. 43 Stacey-road, Routh, Cardiff.
1875. ‡Gaye, Henry S., M.D. Newton Abbot, Devon.
1871. ‡Geddes, John. 9 Melville-crescent, Edinburgh.
1883. §Geddes, John. 33 Portland-street, Southport.
1885. §Geddes, Patrick. 6 James-court, Edinburgh.
1854. ‡Gee, Robert, M.D. 5 Abercromby-square, Liverpool.
1887. §Gee, W. W. Haldane. Owens College, Manchester.
1867. ‡GEIKIE, ARCHIBALD, LL.D., F.R.S. L. & E., F.G.S., Director-General of the Geological Survey of the United Kingdom. Geological Survey Office, Jermyn-street, London, S.W.
1871. ‡GEIKIE, JAMES, LL.D., D.C.L., F.R.S. L. & E., F.G.S., Murchison Professor of Geology and Mineralogy in the University of Edinburgh. 31 Merchiston-avenue, Edinburgh.
1882. *GENESE, R. W., M.A., Professor of Mathematics in University College, Aberystwith.
1875. *George, Rev. Hereford B., M.A., F.R.G.S. New College, Oxford.
1885. ‡Gerard, Robert. Blair-Devenick, Cults, Aberdeen.
1884. *Gerrans, Henry T., M.A. Worcester College, Oxford.
1870. *Gervis, Walter S., M.D., F.G.S. Ashburton, Devonshire.
1884. ‡Gibb, Charles. Abbotsford, Quebec, Canada.
1865. ‡Gibbins, William. Battery Works, Digbeth, Birmingham.
1889. §Gibson, Charles, M.D. 8 Eldon-square, Newcastle-upon-Tyne.
1874. ‡Gibson, The Right Hon. Edward, Q.C. 23 Fitzwilliam-square, Dublin.
1876. *Gibson, George Alexander, M.D., D.Sc., F.R.S.E., Secretary to the Royal College of Physicians of Edinburgh. 17 Alva-street, Edinburgh.
1884. ‡Gibson, Rev. James J. 183 Spadina-avenue, Toronto, Canada.
1885. ‡Gibson, John, Ph.D. The University, Edinburgh.
1889. *Gibson, T. G. 2 Eslington-road, Newcastle-upon-Tyne.
1887. ‡GIFFEN, ROBERT, LL.D., V.P.S.S. 44 Pembroke-road, London, S.W.
1888. *Gifford, H. J. Bute Arms, Pontydown, South Wales.
1884. ‡Gilbert, E. E. 245 St. Antoine-street, Montreal, Canada.
1842. GILBERT, JOSEPH HENRY, Ph.D., LL.D., F.R.S., F.C.S., Professor of Rural Economy in the University of Oxford. Harpenden, near St. Albans.

Year of Election.

1883. §Gilbert, Mrs. Harpenden, near St. Albans.
1857. ‡Gilbert, J. T., M.R.I.A. Villa Nova, Blackrock, Dublin.
1884. *Gilbert, Philip H. 456 St. Urbain-street, Montreal, Canada.
1883. ‡Gilbert, Thomas. Derby-road, Southport.
Gilderdale, Rev. John, M.A. Walthamstow, Essex.
1882. ‡Giles, Alfred, M.P., M.Inst.C.E. Cosford, Godalming.
1878. ‡Giles, Oliver. Crescent Villas, Bromsgrove.
Giles, Rev. William. Netherleigh House, near Chester.
1878. ‡*Gill, Rev. A. W. H* 44 *Eaton-square, London, S.W.*
1871. *Gill, David, LL.D., F.R.S., F.R.A.S. Royal Observatory, Cape Town.
1888. §Gill, John Frederick. Douglas, Isle of Man.
1868. ‡Gill, Joseph. Palermo, Sicily. (Care of W. H. Gill, Esq., General Post Office, St. Martin's-le-Grand, E.C.)
1864. ‡Gill, Thomas. 4 Sydney-place, Bath.
1887. ‡Gillett, Charles Edwin. Wood Green, Banbury, Oxford.
1888. ‡Gilliland, E. T. 259 West Seventy-fourth-street, New York, U.S.A.
1884. ‡Gillman, Henry. 79 East Columbia-street, Detroit, Michigan, U.S.A.
1861. *Gilroy, George. Woodlands, Parbold, near Southport.
1867. ‡Gilroy, Robert. Craigie, by Dundee.
1887. *Gimingham, Charles H. Stamford House, Northumberland Park, Tottenham, Middlesex.
1867. §Ginsburg, Rev. C. D., D.C.L., LL.D. Holmlea, Virginia Water Station, Chertsey.
1884. ‡Girdwood, Dr. G. P. 28 Beaver Hall-terrace, Montreal, Canada.
1874. *Girdwood, James Kennedy. Old Park, Belfast.
1884 ‡Gisborne, Frederick Newton. Ottawa, Canada.
1886. *Gisborne, Hartley. Qu'Appelle Station, Assa, N.W.T., Canada.
1883. *Gladstone, Miss. 17 Pembridge-square, London, W.
1883. *Gladstone, Miss E. A. 17 Pembridge-square, London, W.
1850. *Gladstone, George, F.C.S., F.R.G.S. 34 Denmark-villas, Hove, Brighton.
1849. *Gladstone, John Hall, Ph.D., F.R.S., F.C.S. 17 Pembridge-square, London, W.
1861. *Glaisher, James, F.R.S., F.R.A.S. 1 Dartmouth-place, Blackheath, London, S.E.
1871. *Glaisher, J. W. L., M.A., D.Sc., F.R.S., F.R.A.S. Trinity College, Cambridge.
1883. ‡Glasson, L. T. 2 Roper-street, Penrith.
1881. *Glazebrook, R. T., M.A., F.R.S. Trinity College, Cambridge.
1887. §Glazier, Walter H., F.C.S. Courtlands, East Molesey, Surrey.
1881. *Gleadow, Frederic. Care of H. C. Gleadow, Esq., 5 Cornwall-gardens, London, S.W.
1870. §Glen, David Corse, F.G.S. 14 Annfield-place, Glasgow.
1859. ‡Glennie, J. S. Stuart, M.A. West Bank, Wimbledon Common, Surrey.
1867. ‡Gloag, John A. L. 10 Inverleith-place, Edinburgh.
Glover, George. Ranelagh-road, Pimlico, London, S.W.
1874. ‡Glover, George T. 30 Donegall-place, Belfast.
Glover, Thomas. 124 Manchester-road, Southport.
1887. ‡Glover, Walter T. Moorhurst, Kersal, Manchester.
1870. ‡Glynn, Thomas R., M.D. 62 Rodney-street, Liverpool.
1889. §Goddard, F. R. 19 Victoria-square, Newcastle-upon-Tyne.
1872. ‡Goddard, Richard. 16 Booth-street, Bradford, Yorkshire.
1886. ‡Godlee, Arthur. 3 Greenfield-crescent, Edgbaston, Birmingham.
1887. ‡Godlee, Francis. 51 Portland-street, Manchester.
1878. *Godlee, J. Lister. 3 New-square, Lincoln's Inn, London, W.C.

Year of Election

1880. ‡Godman, F. Du Cane, F.R.S., F.L.S., F.G.S. 10 Chandos-street, Cavendish-square, London, W.
1883. ‡Godson, Dr. Alfred. Cheadle, Cheshire.
1852. ‡Godwin, John. Wood House, Rostrevor, Belfast.
1879. §Godwin-Austen, Lieut.-Colonel H. H., F.R.S., F.G.S., F.R.G.S., F.Z.S. Shalford House, Guildford.
1876. ‡Goff, Bruce, M.D. Bothwell, Lanarkshire.
1886. ‡Goldsmid, Major-General Sir F. J., C.B., K.C.S.I., F.R.G.S. 3 Observatory-avenue, London, W.
1881. ‡Goldschmidt, Edward. Nottingham.
1873. ‡Goldthorp, Miss R. F. C Cleckheaton, Bradford, Yorkshire.
1884. ‡Good, Charles E. 102 St. François Xavier-street, Montreal, Canada.
1878. ‡Good, Rev. Thomas, B.D. 51 Wellington-road, Dublin.
1852. ‡Goodbody, Jonathan. Clare, King's County, Ireland.
1878. ‡Goodbody, Jonathan, jun. 50 Dame-street, Dublin.
1884. ‡Goodbody, Robert. Fairy Hill, Blackrock, Co. Dublin.
1886. ‡Goodman, F. B. 46 Wheeley's-road, Edgbaston, Birmingham.
1885. ‡Goodman, J. D., J.P. Peachfield, Edgbaston, Birmingham.
1865. ‡Goodman, J. D. Minories, Birmingham.
1869. ‡*Goodman, Neville, M.A. Peterhouse, Cambridge.*
1884. §Goodridge, Richard E. W. Oak Bank, Manitoba, Canada.
1884. ‡Goodwin, Professor W. L. Queen's University, Kingston, Ontario, Canada.
1883. ‡Goouch, B., B.A. 2 Oxford-road, Birkdale, Southport.
1885. ‡Gordon, General the Hon. Sir Alexander Hamilton. 50 Queen's Gate-gardens, London, S.W.
1885. §Gordon, Rev. Cosmo, D.D., F.R.A.S., F.G.S. Chetwynd Rectory, Newport, Salop.
1885. ‡Gordon, Rev. George, LL.D. Birnie, by Elgin, N.B.
1871. *Gordon, Joseph Gordon, F.C.S. Queen Anne's Mansions, Westminster, S.W.
1884. *Gordon, Robert, M.Inst.C.E., F.R.G.S. Fernhill, Henbury, near Bristol.
1857. ‡Gordon, Samuel, M.D. 11 Hume-street, Dublin.
1885. ‡Gordon, Rev. William. Braemar, N.B.
1887. §Gordon, William John. 21 Catherstone-terrace, London, S.W.
1865. ‡Gore, George, LL.D., F.R.S. 50 Islington-row, Edgbaston, Birmingham.
1875. *Gotch, Francis, B.A., B.Sc. Holywell Cottage, Oxford.
*Gotch, Rev. Frederick William, LL.D. Stokes' Croft, Bristol.
*Gotch, Thomas Henry. Kettering.
1873. ‡Gott, Charles, M.Inst.C.E. Parkfield-road, Manningham, Bradford, Yorkshire.
1849. ‡Gough, The Hon. Frederick. Perry Hall, Birmingham.
1857. ‡Gough, The Right Hon. George S., Viscount, M.A., F.L.S., F.G.S. St. Helen's, Booterstown, Dublin.
1881. ‡Gough, Thomas, B.Sc., F.C.S. Elmfield College, York.
1868. ‡Gould, Rev. George. Unthank-road, Norwich.
1888. ‡Gouraud, Colonel. Little Menlo, Norwood, Surrey.
1873. ‡Gourlay, J. McMillan. 21 St. Andrew's-place, Bradford, Yorkshire.
1867. ‡Gourley, Henry (Engineer). Dundee.
1876. ‡Gow, Robert. Cairndowan, Dowanhill, Glasgow.
1883. §Gow, Mrs. Cairndowan, Dowanhill, Glasgow.
Gowland, James. London-wall, London, E.C.
1873. §Goyder, Dr. D. Marley House, 88 Great Horton-road, Bradford, Yorkshire.
1886. ‡Grabham, Michael C., M.D. Madeira.

Year of Election.

1861. ‡Grafton, Frederick W. Park-road, Whalley Range, Manchester.
1867. *GRAHAM, CYRIL, C.M.G., F.L.S., F.R.G.S. Travellers' Club, Pall Mall, London, S.W.
1875. ‡GRAHAME, JAMES. 12 St. Vincent-street, Glasgow.
1852. *GRAINGER, Rev. Canon JOHN, D.D., M.R.I.A. Skerry and Rathcavan Rectory, Broughshane, near Ballymena, Co. Antrim.
1870. ‡GRANT, Colonel JAMES A., C.B., C.S.I., F.R.S., F.L.S., F.R.G.S. 19 Upper Grosvenor-street, London, W.
1855. *GRANT, ROBERT, M.A., LL.D., F.R.S., F.R.A.S., Regius Professor of Astronomy in the University of Glasgow. The Observatory, Glasgow.
1854. ‡GRANTHAM, RICHARD B., M.Inst.C.E., F.G.S. Northumberland-chambers, Northumberland-avenue, London, W.C.
1864. ‡Grantham, Richard F. Northumberland-chambers, Northumberland-avenue, London, W.C.
1887. §Gratrix, Samuel. Alport Town, Manchester.
1881. ‡Graves, E. 22 Trebovir-road, Earl's Court-road, London, S.W.
1887. ‡*Graves, John. Broomhurst, Eccles Old-road, Manchester.*
1881. ‡Gray, Alan, LL.B. Minster-yard, York.
1864. *Gray, Rev. Charles. The Vicarage, Blyth, Worksop.
1865. ‡Gray, Charles. Swan Bank, Bilston.
1876. ‡Gray, Dr. Newton-terrace, Glasgow.
1881. ‡Gray, Edwin, LL.B. Minster-yard, York.
1859. ‡*Gray, Rev. J. H. Bolsover Castle, Derbyshire.*
1887. §Gray, Joseph W., F.G.S. Spring Hill, Wellington-road South, Stockport.
1887. ‡Gray, M. H., F.G.S. Lessness Park, Abbey Wood, Kent.
1886. *Gray, Robert Kaye. Lessness Park, Abbey Wood, Kent.
1881. ‡Gray, Thomas, Professor of Engineering in the Rane Technical Institute, Terre Haute, Indiana, U.S.A.
1873. ‡Gray, William, M.R.I.A. 8 Mount Charles, Belfast.
*GRAY, Colonel WILLIAM. Farley Hall, near Reading.
1883. ‡Gray, William Lewis. 36 Gutter-lane, London, E.C.
1883. ‡Gray, Mrs. W. L. 36 Gutter-lane, London, E.C.
1886. ‡Greaney, Rev. William. Bishop's House, Bath-street, Birmingham.
1883. §Greathead, J. H. 8 Victoria-chambers, London, S.W.
1866. §Greaves, Charles Augustus, M.B., LL.B. 101 Friar-gate, Derby.
1887. ‡Greaves, H. R. The Orchards, Mill End, Stockport.
1869. ‡Greaves, William. Station-street, Nottingham.
1872. ‡Greaves, William. 3 South-square, Gray's Inn, London, W.C.
1872. *Grece, Clair J., LL.D. Redhill, Surrey.
1879. ‡*Green, A. F.* 15 *Ashwood-villas, Headingley, Leeds.*
1889. §Green, A. H., M.A., F.R.S., F.G.S., Professor of Geology in the University of Oxford. 137 Woodstock-road, Oxford.
1888. §GREEN, JOSEPH R. 17 Bloomsbury-square, London, W.C.
1887. §Greene, Friese. 34 Gay-street, Bath.
1887. ‡Greenhalgh, Richard. 1 Temple-gardens, The Temple, London, E.C.
1858. *Greenhalgh, Thomas. Thornydikes, Sharples, near Bolton-le-Moors.
1882. ‡GREENHILL, A. G., M.A., F.R.S., Professor of Mathematics in the Royal Artillery College, Woolwich. 3 Staple Inn, London, W.C.
1881. §Greenhough, Edward. Matlock Bath, Derbyshire.
1884. ‡Greenish, Thomas, F.C.S. 20 New-street, Dorset-square, London, N.W.
1884. ‡Greenshields, E. B. Montreal, Canada.
1884. ‡Greenshields, Samuel. Montreal, Canada.
1887. §Greenwell, G. C., jun. Poynton, Cheshire.

Year of Election.

1863. ‡Greenwell, G. E. Poynton, Cheshire.
1889. §Greenwell, T. G. Woodside, Sunderland.
1875. ‡*Greenwood, Frederick. School of Medicine, Leeds.*
1877. ‡Greenwood, Holmes. 78 King-street, Accrington.
1883. ‡GREENWOOD, J. G., LL.D., Vice-Chancellor of Victoria University. Owens College, Manchester.
1849. ‡Greenwood, William. Stones, Todmorden.
1887. §Greenwood, Professor W. H., M.Inst.C.E. Firth College, Sheffield.
1887. *Greg, Arthur. Eagley, near Bolton, Lancashire.
1861. *GREG, ROBERT PHILIPS, F.G.S., F.R.A.S. Coles Park, Buntingford, Herts.
1833. Gregg, T. H. 12 Alexandra-road, Finsbury Park, London, N.
1860. ‡GREGOR, Rev. WALTER, M.A. Pitsligo, Rosehearty, Aberdeenshire.
1868. ‡Gregory, Sir Charles Hutton, K.C.M.G., M.Inst.C.E. 2 Delahay-street, Westminster, S.W.
1883. ‡Gregson, Edward, Ribble View, Preston.
1883. ‡Gregson, G. E. Ribble View, Preston.
1881. ‡Gregson, William. Baldersby, Thirsk.
1875. ‡Grenfell, J. Granville, B.A., F.G.S. 5 Albert-villas, Clifton, Bristol.
1875. ‡*Grey, Mrs. Maria G.* 18 *Cadogan-place, London, S.W.*
1859. ‡GRIERSON, THOMAS BOYLE, M.D. Thornhill, Dumfries-shire.
1878. ‡Griffin, Robert, M.A., LL.D. Trinity College, Dublin.
1859. *GRIFFITH, GEORGE, M.A., F.C.S. Druries, Harrow.
1870. ‡Griffith, Rev. Henry, F.G.S. Brooklands, Isleworth, Middlesex.
1884. ‡Griffiths, E. H. 12 Park-side, Cambridge.
1884. ‡Griffiths, Mrs. 12 Park-side, Cambridge.
1847. ‡Griffiths, Thomas. Bradford-street, Birmingham.
1879. ‡Griffiths, Thomas, F.C.S., F.S.S. Heidelberg House, King's-road, Clapham Park, London, S.W.
1875. ‡Grignon, James, H.M. Consul at Riga. Riga.
1870. ‡Grimsdale, T. F., M.D. 29 Rodney-street, Liverpool.
1888. *Grimshaw, James Walter. Australian Club, Sydney, New South Wales.
1884. ‡Grinnell, Frederick. Providence, Rhode Island, U.S.A.
1881. ‡Gripper, Edward. Nottingham.
1864. ‡GROOM-NAPIER, CHARLES OTTLEY. 18 Elgin-road, St. Peter's Park, London, N.W.
GROVE, The Hon. Sir WILLIAM ROBERT, Knt., M.A., D.C.L., LL.D., F.R.S. 115 Harley-street, London, W.
1863. *GROVES, THOMAS B., F.C.S. 80 St. Mary-street, Weymouth.
1869. ‡GRUBB, Sir HOWARD, F.R.S., F.R.A.S. 51 Kenilworth-square, Rathgar, Dublin.
1886. §Grundy, John. Park Drive, Nottingham.
1867. ‡Guild, John. Bayfield, West Ferry, Dundee.
1887. ‡GUILLEMARD, F. H. H. Eltham, Kent.
Guinness, Henry. 17 College-green, Dublin.
1842. Guinness, Richard Seymour. 17 College-green, Dublin.
1862. ‡Gunn, John, M.A., F.G.S. 82 Prince of Wales-road, Norwich.
1885. ‡Gunn, John. Dale, Halkirk, Caithness.
1877. ‡Gunn, William, F.G.S. Office of the Geological Survey of Scotland, Sheriff's Court House, Edinburgh.
1866. ‡GÜNTHER, ALBERT C. L. G., M.A., M.D., Ph.D., F.R.S., Keeper of the Zoological Collections in the British Museum. British Museum, South Kensington, London, S.W.
1880. §Guppy, John J. Ivy-place, High-street, Swansea.
1876. ‡Guthrie, Francis. Cape Town, Cape of Good Hope.

Year of Election.

1883. ‡Guthrie, Malcolm. 2 Parkfield-road, Liverpool.
1857. ‡Gwynne, Rev. John. Tullyagnish, Letterkenny, Strabane, Ireland.
1876. ‡GWYTHER, R. F., M.A. Owens College, Manchester.

1884. ‡Haanel, E., Ph.D. Cobourg, Ontario, Canada.
1887. ‡Hackett, Henry Eugene. Hyde-road, Gorton, Manchester.
1865. ‡Hackney, William. 9 Victoria-chambers, Victoria-street, London, S.W.
1884. ‡Hadden, Captain C. F., R.A. Woolwich.
1881. *HADDON, ALFRED CORT, B.A., F.Z.S., Professor of Zoology in the Royal College of Science, Dublin.
Haden, G. N. Trowbridge, Wiltshire.
1842. Hadfield, George. Victoria-park, Manchester.
1888. *Hadfield, R. A. Hecla Works, Sheffield.
1870. ‡Haigh, George. Waterloo, Liverpool.
*Hailstone, Edward, F.S.A. Walton Hall, Wakefield, Yorkshire.
1879. ‡HAKE, H. WILSON, Ph.D., F.C.S. Queenwood College, Hants.
1875. ‡Hale, Rev. Edward, M.A., F.G.S., F.R.G.S. Eton College, Windsor.
1887. ‡Hale, The Hon. E. J. 9 Mount-street, Manchester.
1883. ‡*Haliburton, Robert Grant. National Club, Whitehall, London, S.W.*
1872. ‡Hall, Dr. Alfred. 8 Mount Ephraim, Tunbridge Wells.
1879. *Hall, Ebenezer. Abbeydale Park, near Sheffield.
1883. **Hall, Miss Emily. 24 Scarisbrick-street, Southport.*
1881. ‡Hall, Frederick Thomas, F.R.A.S. 15 Gray's Inn-square, London, W.C.
1854. *HALL, HUGH FERGIE, F.G.S. Sunnyside, Wavertree, Liverpool.
1887. ‡Hall, John. Springbank, Leftwich, Northwich.
1872. *Hall, Captain Marshall, F.G.S. St. John's, Bovey Tracey, South Devon.
1885. §Hall, Samuel. 19 Aberdeen Park, Highbury, London, N.
1884. ‡Hall, Thomas Proctor. School of Practical Science, Toronto, Canada.
1866. *HALL, TOWNSHEND M., F.G.S. Orchard House, Pilton, Barnstaple.
1860. ‡Hall, Walter. 11 Pier-road, Erith.
1873. *HALLETT, T. G. P., M.A. Claverton Lodge, Bath.
1868. *HALLETT, WILLIAM HENRY, F.L.S. Buckingham House, Marine Parade, Brighton.
1888. §Halliburton, W. D., M.D. 25 Maitland Park-villas, London, N.W.
Halsall, Edward. 4 Somerset-street, Kingsdown, Bristol.
1886. ‡Hambleton, G. W. 76 Upper Gloucester-place, London, N.W.
1858. *Hambly, Charles Hambly Burbridge, F.G.S. Holmeside, Hazelwood, Derby.
1883. *Hamel, Egbert D. de. Middleton Hall, Tamworth.
1885. ‡Hamilton, David James. 1A Albyn-place, Aberdeen.
1869. ‡Hamilton, Rowland. Oriental Club, Hanover-square, London, W.
1888. *HAMMOND, ANTHONY, J.P. Bath.
1851. ‡Hammond, C. C. Lower Brook-street, Ipswich.
1881. *Hammond, Robert. Hilldrop, Highgate, London, N.
1878. ‡Hanagan, Anthony. Luckington, Dalkey.
1878. §Hance, Edward M., LL.B. 6 Sea Bank-avenue, Egremont, Cheshire.
1875. ‡Hancock, C. F., M.A. 125 Queen's-gate, London, S.W.
1863. ‡Hancock, John. 4 St. Mary's-terrace, Newcastle-on-Tyne.
1861. ‡Hancock, Walter. 10 Upper Chadwell-street, Pentonville, London, E.C.
1857. ‡Hancock, William J. 23 Synnot-place, Dublin.
1847. ‡HANCOCK, W. NEILSON, LL.D., M.R.I.A. 64 Upper Gardiner-street, Dublin.

Year of Election.

1876. ‡Hancock, Mrs. W. Neilson. 64 Upper Gardiner-street, Dublin.
1882. ‡Hankinson, R. C. Bassett, Southampton.
1884. §Hannaford, E. C. 1591 Catherine-street, Montreal, Canada.
1859. ‡Hannay, John. Montcoffer House, Aberdeen.
1886. §Hansford, Charles. 3 Alexandra-terrace, Dorchester.
1859. *HARCOURT, A. G. VERNON, M.A., D.C.L., LL.D., F.R.S., F.C.S. (GENERAL SECRETARY.) Cowley Grange, Oxford.
1886. *Hardcastle, Basil W., F.S.S. Beechenden, Hampstead, London, N.W.
1884. *Hardcastle, Norman C., M.A., LL.D. Downing College, Cambridge.
1865. ‡Harding, Charles. Harborne Heath, Birmingham.
1869. ‡Harding, Joseph. Millbrook House, Exeter.
1877. ‡Harding, Stephen. Bower Ashton, Clifton, Bristol.
1869. ‡Harding, William D. Islington Lodge, King's Lynn, Norfolk.
1886. ‡Hardman, John B. St. John's, Hunter's-lane, Birmingham.
1880. ‡Hardy, John. 118 Embden-street, Manchester.
1838. *HARE, CHARLES JOHN, M.D. Berkeley House, 15 Manchester-square, London, W.
1858. ‡Hargrave, James. Burley, near Leeds.
1883. ‡Hargreaves, Miss H. M. 69 Alexandra-road, Southport.
1883. ‡Hargreaves, Thomas. 69 Alexandra-road, Southport.
1881. ‡Hargrove, William Wallace. St. Mary's, Bootham, York.
1876. ‡Harker, Allen, F.L.S., Professor of Natural History in the Royal Agricultural College, Cirencester.
1887. ‡Harker, T. H. Brook House, Fallowfield, Manchester.
1878. *Harkness, H. W. California Academy of Sciences, San Francisco, California, U.S.A.
1871. ‡Harkness, William, F.C.S. Laboratory, Somerset House, London, W.C.
1875. *Harland, Rev. Albert Augustus, M.A., F.G.S., F.L.S., F.S.A. The Vicarage, Harefield, Middlesex.
1877. *Harland, Henry Seaton. 8 Arundel-terrace, Brighton, Sussex.
1883. *Harley, Miss Clara. 4 Wellington-square, Oxford.
1862. *HARLEY, GEORGE, M.D., F.R.S., F.C.S. 25 Harley-street, London, W.
1883. *Harley, Harold. 14 Chapel-street, Bedford-row, London, W.C.
1862. *HARLEY, Rev. ROBERT, M.A., F.R.S., F.R.A.S. 4 Wellington-square, Oxford.
1868. *HARMER, F. W., F.G.S. Oakland House, Cringleford, Norwich.
1881. *HARMER, SIDNEY F., M.A., B.Sc. King's College, Cambridge.
1882. ‡Harper, G. T. Bryn Hyfrydd, Portswood, Southampton.
1872. ‡Harpley, Rev. William, M.A. Clayhanger Rectory, Tiverton.
1884. ‡Harrington, B. J., B.A., Ph.D., Professor of Chemistry and Mineralogy in McGill University, Montreal. Wallbrae-place, Montreal, Canada.
1872. *Harris, Alfred. Lunefield, Kirkby Lonsdale, Westmoreland.
1888. ‡Harris, C. T. 4 Kilburn Priory, London, N.W.
1871. ‡HARRIS, GEORGE, F.S.A. Iselipps Manor, Northolt, Southall, Middlesex.
1842. *Harris, G. W., M.Inst.C.E. Mount Gambier, South Australia.
1889. §Harris, H. Graham, M.Inst.C.E. 5 Great George-street, Westminster, S.W.
1884. ‡Harris, Miss Katherine E. 73 Albert Hall-mansions, Kensington-gore, London, S.W.
1888. ‡Harrison, Charles. 20 Lennox-gardens, London, S.W.
1860. ‡Harrison, Rev. Francis, M.A. North Wraxall, Chippenham.
1864. ‡Harrison, George. Barnsley, Yorkshire.

Year of Election.

1874. ‡Harrison, G. D. B. 3 Beaufort-road, Clifton, Bristol.
1858. *HARRISON, JAMES PARK, M.A. 22 Connaught-street, Hyde Park, London, W.
1889. §Harrison, J. C. Oxford House, Castle-road, Scarborough.
1870. ‡HARRISON, REGINALD, F.R.C.S. 6 Lower Berkeley-street, Portman-square, London, W.
1853. ‡Harrison, Robert. 36 George-street, Hull.
1883. ‡*Harrison, Thomas. 34 Ash-street, Southport.*
1886. §Harrison, William. The Horsehills, Wolverhampton.
1886. ‡Harrison, W. Jerome, F.G.S. 365 Lodge-road, Hockley, Birmingham.
1885. ‡HART, CHARLES J. 10 Calthorpe-road, Edgbaston, Birmingham.
1876. *Hart, Thomas. Brooklands, Blackburn.
1881. §Hart, Thomas, F.G.S. Yewbarrow, Grange-over-Sands, Carnforth.
1875. ‡Hart, W. E. Kilderry, near Londonderry.
Hartley, James. Sunderland.
1871. ‡HARTLEY, WALTER NOEL, F.R.S. L. & E., F.C.S., Professor of Chemistry in the Royal College of Science, Dublin.
1886. §HARTOG, Professor M. M., D.Sc. Queen's College, Cork.
1887. §Hartog, P. J., B.Sc. 6 Greville-road, London, N.W.
1870. ‡Harvey, Enoch. Riversdale-road, Aigburth, Liverpool.
1885. ‡Harvey, Surgeon-Major Robert, M.D. Calcutta.
1885. §Harvie-Brown, J. A. Dunipace, Larbert, N.B.
1862. *Harwood, John, jun. Woodside Mills, Bolton-le-Moors.
1884. ‡Haslam, Rev. George, M.A. Trinity College, Toronto, Canada.
1882. ‡Haslam, George James, M.D. Owens College, Manchester.
1875. *HASTINGS, G. W., M.P. Barnard's Green House, Malvern.
1889. §Hatch, Dr. F. H. 28 Jermyn-street, London, S.W.
1886. ‡Hatherton, The Right Hon. Lord, C.B. Haws Hall, Birmingham.
1857. ‡HAUGHTON, Rev. SAMUEL, M.A., M.D., D.C.L., LL.D., F.R.S., M.R.I.A., F.G.S., Senior Fellow of Trinity College, Dublin. Trinity College, Dublin.
1874. ‡Hawkins, B. Waterhouse, F.G.S. Century Club, East Fifteenth-street, New York, U.S.A.
1887. *Hawkins, William. 11 Fountain-street, Manchester.
1872. *Hawkshaw, Henry Paul. 58 Jermyn-street, St. James's, London, S.W.
*HAWKSHAW, Sir JOHN, M.Inst.C.E., F.R.S., F.G.S., F.R.G.S. Hollycombe, Liphook, Petersfield; and 33 Great George-street, London, S.W.
1864. *HAWKSHAW, JOHN CLARKE, M.A., M.Inst.C.E., F.G.S. 50 Harrington-gardens, South Kensington, S.W.; and 33 Great George-street London, S.W.
1868. §HAWKSLEY, THOMAS, M.Inst.C.E., F.R.S., F.G.S. 30 Great George-street, London, S.W.
1884. *Haworth, Abraham. Hilston House, Altrincham.
1889. §Haworth, George C. Ordsal-lane, Salford.
1887. *Haworth, Jesse. Woodside, Bowdon, Cheshire.
1887. ‡Haworth, S. E. Warsley-road, Swinton, Manchester.
1886. ‡Haworth, Rev. T. J. Albert Cottage, Saltley, Birmingham.
1863. ‡Hawthorn, William. The Cottage, Benwell, Newcastle-upon-Tyne.
1877. ‡Hay, Arthur J. Lerwick, Shetland.
1861. *HAY, Admiral the Right Hon. Sir JOHN C. D., Bart., K.C.B., D.C.L., F.R.S. 108 St. George's-square, London, S.W.
1858. ‡*Hay, Samuel. Albion-place, Leeds.*
1867. ‡Hay, William. 21 Magdalen-yard-road, Dundee.
1885. *Haycraft, Professor John Berry, M.B., B.Sc., F.R.S.E. Physiological Laboratory, The University, Edinburgh.

Year of Election.

1873. *Hayes, Rev. William A., M.A. Dromore, Co. Down, Ireland.
1869. ‡Hayward, J. High-street, Exeter.
1858. *HAYWARD, ROBERT BALDWIN, M.A., F.R.S. Fishers, Harrow.
1888. ‡Hazard, Rowland R. Little Mulgrave House, Hurlingham.
1879. **Hazlehurst, George S. Rhyl, North Wales.*
1851. §HEAD, JEREMIAH, M.Inst.C.E., F.C.S. Middlesbrough, Yorkshire.
1869. ‡*Head, R. T. The Briars, Alphington, Exeter.*
1883. ‡Headley, Frederick Halcombe. Manor House, Petersham, S.W.
1883. ‡Headley, Mrs. Marian. Manor House, Petersham, S.W.
1883. §Headley, Rev. Tanfield George. Manor House, Petersham, S.W.
1871. §Healey, George. Brantfield, Bowness, Windermere.
1883. *Heap, Ralph, jun. 1 Brick-court, Temple, London, E.C.
1861. *Heape, Benjamin. Northwood, Prestwich, near Manchester.
1883. ‡Heape, Charles. Tovrak, Oxton, Cheshire.
1883. ‡Heape, Joseph R. 96 Tweedale-street, Rochdale.
1882. *Heape, Walter, M.A. Northwood, Prestwich, Manchester.
1877. ‡Hearder, Henry Pollington. Westwell-street, Plymouth.
1877. ‡Hearder, William Keep, F.S.A. 195 Union-street, Plymouth.
1883. ‡Heath, Dr. 46 Hoghton-street, Southport.
1889. §Heath, Dr. Westgate-road, Newcastle-upon-Tyne.
1866. ‡Heath, Rev. D. J. Esher, Surrey.
1863. ‡Heath, G. Y., M.D. Westgate-street, Newcastle-on-Tyne.
1884. ‡Heath, Thomas, B.A. Royal Observatory, Calton Hill, Edinburgh.
1861. ‡HEATHFIELD, W. E., F.C.S., F.R.G.S., F.R.S.E. 1 Powis-grove, Brighton; and Arthur's Club, St. James's, London, S.W.
1883. ‡Heaton, Charles. Marlborough House, Hesketh Park, Southport.
1886. ‡Heaton, C. W. Tower House, Belvedere, Kent.
1886. ‡Heaton, Miss Ellen. Woodhouse-square, Leeds.
1865. ‡Heaton, Harry. Harborne House, Harborne, near Birmingham.
1889. *Heaviside, Arthur West. 7 Grafton-road, Whitley, Newcastle-upon-Tyne.
1884. §Heaviside, Rev. George, B.A., F.R.G.S., F.R.Hist.S. The Hollies, Stoke, Coventry.
1833. ‡HEAVISIDE, Rev. Canon J. W. L., M.A. The Close, Norwich.
1888. *Heawood, Edward, B.A., F.G.S. 41 Old Elvet, Durham.
1888. *Heawood, Percy Y., Lecturer in Mathematics at Durham University. 41 Old Elvet, Durham.
1855. ‡HECTOR, Sir JAMES, K.C.M.G., M.D., F.R.S., F.G.S., F.R.G.S., Director of the Geological Survey of New Zealand. Wellington, New Zealand.
1867. ‡Heddle, M. Forster, M.D., F.R.S.E. St. Andrews, N.B.
1869. ‡Hedgeland, Rev. W. J. 21 Mount Radford, Exeter.
1882. ‡Hedger, Philip. Cumberland-place, Southampton.
1887. *Hedges, Killingworth, M.Inst.C.E. 25 Queen Anne's-gate, London, S.W.
1863. ‡Hedley, Thomas. Cox Lodge, near Newcastle-upon-Tyne.
1887. §Hembry, Frederick William, F.R.M.S. Sussex Lodge, Sidcup, Kent.
1867. ‡Henderson, Alexander. Dundee.
1873. *Henderson, A. L. 277 Lewisham High-road, London, S.E.
1883. ‡Henderson, Mrs. A. L. 277 Lewisham High-road, London, S.E.
1880. *Henderson, Captain W. H., R.N. 21 Albert Hall Mansions, London, S.W.
1876. *Henderson, William. Williamfield, Irvine, N.B.
1885. ‡Henderson, William. Devanha House, Aberdeen.
1856. ‡HENNESSY, HENRY G., F.R.S., M.R.I.A., Professor of Applied Mathematics and Mechanics in the Royal College of Science for Ireland. Brookvale, Donnybrook, Co. Dublin.

Year of Election.

1857. ‡Hennessy, Sir John Pope, K.C.M.G., Governor and Commander-in-Chief of Mauritius.
1873. *HENRICI, OLAUS M. F. E., Ph.D., F.R.S., Professor of Mechanics and Mathematics in the City and Guilds of London Institute. Central Institution, Exhibition-road, London, S.W.
Henry, Franklin. Portland-street, Manchester.
1873. Henry, J. Snowdon. East Dene, Bonchurch, Isle of Wight.
Henry, Mitchell. Stratheden House, Hyde Park, London, W.
*HENRY, WILLIAM CHARLES, M.D., F.R.S., F.G.S., F.R.G.S., F.C.S. Haffield, near Ledbury, Herefordshire.
1884. ‡Henshaw, George H. 43 Victoria-street, Montreal, Canada.
1870. ‡Henty, William. 12 Medina-villas, Brighton.
1855. *Hepburn, J. Gotch, LL.B., F.C.S. Dartford, Kent.
1855. ‡Hepburn, Robert. 9 Portland-place, London, W.
1887. *Herdman, William A., D.Sc., Professor of Natural History in University College, Liverpool.
1871. *HERSCHEL, ALEXANDER S., M.A., D.C.L., F.R.S., F.R.A.S., Honorary Professor of Experimental Physics in the University of Durham College of Science, Newcastle-on-Tyne. Observatory House, Slough, Bucks.
1874. §HERSCHEL, Colonel JOHN, R.E., F.R.S., F.R.A.S. Observatory House, Slough, Bucks.
1884. §Hewett, George Edwin. Cotswold House, St. John's Wood Park, London, N.W.
1883. ‡Hewson, Thomas. Care of J. C. C. Payne, Esq., Botanic-avenue, The Plains, Belfast.
1881. ‡Hey, Rev. William Croser, M.A. Clifton, York.
1882. ‡Heycock, Charles T., B.A. King's College, Cambridge.
1883. §Heyes, Rev. John Frederick, M.A., F.C.S., F.R.G.S. 9 King-street, Oxford.
1866. *Heymann, Albert. West Bridgford, Nottinghamshire.
1879. ‡Heywood, A. Percival. Duffield Bank, Derby.
1861. *Heywood, Arthur Henry. Elleray, Windermere.
1886. §Heywood, Henry. Cardiff.
*HEYWOOD, JAMES, F.R.S., F.G.S., F.S.A., F.R.G.S., F.S.S. 26 Kensington Palace-gardens, London, W.
1861. *HEYWOOD, OLIVER, J.P., D.L. Claremont, Manchester.
1887. ‡Heywood, Robert. Mayfield, Victoria Park, Manchester.
Heywood, Thomas Percival. Claremont, Manchester.
1888. §Hichens, James Harvey, M.A., F.G.S. Radley College, Abingdon.
1881. ‡Hick, Thomas, B.A., B.Sc. Brighton-grove, Rusholme, Manchester.
1875. ‡HICKS, HENRY, M.D., F.R.S., F.G.S. Hendon Grove, Hendon, Middlesex, N.W.
1877. §HICKS, Professor W. M., M.A., F.R.S., Principal of Firth College, Sheffield. Firth College, Sheffield.
1886. §Hicks, Mrs. W. M. Duvheved, Endcliffe-crescent, Sheffield.
1884. ‡Hickson, Joseph. 272 Mountain-street, Montreal, Canada.
1887. *HICKSON, SYDNEY J., M.A., D.Sc. 35 Highbury New Park, London, N.
1864. *HIERN, W. P., M.A. Castle House, Barnstaple.
1875. ‡Higgins, Charles Hayes, M.D., M.R.C.P., F.R.C.S., F.R.S.E. Alfred House, Birkenhead.
1871. ‡HIGGINS, CLEMENT, B.A., F.C.S. 103 Holland-road, Kensington, London, W.
1854. ‡HIGGINS, Rev. HENRY H., M.A. 29 Falkner-square, Liverpool.
Hildyard, Rev. James, B.D., F.C.P.S. Ingoldsby, near Grantham, Lincolnshire.

Year of Election.

1885. *Hill, Alexander, M.A., M.D. Downing College, Cambridge.
Hill, Arthur. Bruce Castle, Tottenham, Middlesex.
1883. §Hill, Berkeley, M.B., Professor of Clinical Surgery in University College, London. 66 Wimpole-street, London, W.
1872. §Hill, Charles, F.S.A. Rockhurst, West Hoathley, East Grinstead.
1881. §Hill, Rev. Edwin, M.A., F.G.S. St. John's College, Cambridge.
1887. ‡Hill, G. H. Albert-chambers, Albert-square, Manchester.
1884. ‡Hill, Rev. James Edgar, M.A., B.D. 2488 St. Catherine-street, Montreal, Canada.
1857. §Hill, John, M.Inst.C.E., M.R.I.A., F.R.G.S.I. County Surveyor's Office, Ennis, Ireland.
1871. ‡*Hill, Lawrence. The Knowe, Greenock.*
1886 ‡Hill, M. J. M. 16 Pembury-road, Lower Clapton, London, E.
1881. ‡Hill, Pearson. 50 Belsize Park, London, N.W.
1872. *Hill, Rev. Canon, M.A., F.G.S. Sheering Rectory, Harlow.
1885. *Hill, Sidney. Langford House, Langford, Bristol.
1888. §Hill, William. Hitchin, Herts.
1876. ‡Hill, William H. Barlanark, Shettleston, N.B.
1885. *Hillhouse, William, M.A., Professor of Botany in Mason Science College, Birmingham. 95 Harborne-road, Edgbaston, Birmingham.
1886. §Hillier, Rev. E. J. Cardington Vicarage, Bedford.
1863. ‡Hills, F. C. Chemical Works, Deptford, Kent, S.E.
1871. *Hills, Thomas Hyde. 225 Oxford-street, London, W.
1887. ‡Hilton, Edwin. Oak Bank, Fallowfield, Manchester.
1858. ‡Hincks, Rev. Thomas, B.A., F.R.S. Stokeleigh, Leigh Woods, Clifton, Bristol.
1870. ‡Hinde, G. J., Ph.D., F.G.S. Avondale-road, Croydon, Surrey.
1883. *Hindle, James Henry. 67 Avenue-parade, Accrington.
1888. *Hindmarsh, William Thomas, F.L.S. Alnbank, Alnwick.
1886. ‡Hingley, Benjamin, M.P. Hatherton Lodge, Cradley, Worcestershire.
1881. ‡Hingston, J. T. Clifton, York.
1884. ‡Hingston, William Hales, M.D., D.C.L. 37 Union-avenue Montreal, Canada.
1884. ‡Hirschfilder, C. A. Toronto, Canada.
1858. ‡Hirst, John, jun. Dobcross, near Manchester.
1861. *Hirst, T. Archer, Ph.D., F.R.S., F.R.A.S. 7 Oxford and Cambridge Mansions, Marylebone-road, London, N.W.
1884. ‡Hoadrey, John Chipman. Boston, Massachusetts, U.S.A.
Hoare, J. Gurney. Hampstead, London, N.W.
1881. §Hobbes, Robert George. Livingstone House, 374 Wandsworth-road, London, S.W.
1864. ‡*Hobhouse, Arthur Fane. 24 Cadogan-place, London, S.W.*
1864. ‡*Hobhouse, Charles Parry. 24 Cadogan-place, London, S.W.*
1864. ‡*Hobhouse, Henry William. 24 Cadogan-place, London, S.W.*
1879. §Hobkirk, Charles P., F.L.S. West Riding Union Bank, Dewsbury.
1887. *Hobson, Bernard, B.Sc. Tapton Elms, Sheffield.
1883. ‡Hobson, Rev. E. W. 55 Albert-road, Southport.
1877. ‡Hockin, Edward. Poughill, Stratton, Cornwall.
1883. ‡Hocking, Rev. Silas K. 21 Scarisbrick New-road, Southport.
1877. ‡Hodge, Rev. John Mackey, M.A. 38 Tavistock-place, Plymouth.
1876. ‡Hodges, Frederick W. Queen's College, Belfast.
1852. ‡Hodges, John F., M.D., F.C.S., Professor of Agriculture in Queen's College, Belfast.
1863. *Hodgkin, Thomas, B.A., D.C.L. Benwell Dene, Newcastle-upon-Tyne
1887. *Hodgkinson, Alexander. 18 St. John-street, Manchester.

Year of Election.

1880. §Hodgkinson, W. R. Eaton, Ph.D., F.R.S.E., Professor of Chemistry and Physics in the Royal Artillery College, Woolwich. 75 Vanbrugh Park, Blackheath, London, S.E.
1873. *Hodgson, George. Thornton-road, Bradford, Yorkshire.
1873. ‡*Hodgson, James. Oakfield, Manningham, Bradford, Yorkshire.*
1884. ‡Hodgson, Jonathan. Montreal, Canada.
1863. ‡Hodgson, Robert. Whitburn, Sunderland.
1863. ‡Hodgson, R. W. 7 Sandhill, Newcastle-upon-Tyne.
1889. §Hoey, D. G. 8 Gordon-street, Glasgow.
1865. *Hofmann, August Wilhelm, M.D., LL.D., Ph.D., F.R.S., F.C.S. 10 Dorotheen-strasse, Berlin.
1854. *Holcroft, George. Tyddyn-Gwladis, Gaullwyd, near Dolgelly, North Wales.
1883. ‡Holden, Edward. Laurel Mount, Shipley, Yorkshire.
1873. *Holden, Isaac, M.P. Oakworth House, near Keighley, Yorkshire.
1883. ‡Holden, James. 12 Park-avenue, Southport.
1883. ‡Holden, John J. 23 Duke-street, Southport.
1884. ‡Holden, Mrs. Mary E. Dunham Ladies' College, Quebec, Canada.
1857. *Holder, Henry William. Owens College, Manchester.
1887. *Holdsworth, C. J. Oxenholme, Westmoreland.
1879. ‡Holland, Calvert Bernard. Ebbw Vale, South Wales.
*Holland, Philip H. 3 Heath-rise, Willow-road, Hampstead, London, N.W.
1889. §Hollander, Bernard. Unionist Club, 68 Pall Mall, London, S.W.
1886. ‡Holliday, J. R. 101 Harborne-road, Birmingham.
1865. ‡Holliday, William. New-street, Birmingham.
1883. ‡Hollingsworth, Dr. T. S. Elford Lodge, Spring Grove, Isleworth, Middlesex.
1883. *Holmes, Mrs. Basil. 5 Freeland-road, Ealing, Middlesex, W.
1866. *Holmes, Charles. 59 London-road, Derby.
1873. ‡Holmes, J. R. Southbrook Lodge, Bradford, Yorkshire.
1889. §Holmes, Ralph, B.A. Hulme Grammar School, Manchester.
1882. *Holmes, Thomas Vincent, F.G.S. 28 Croom's-hill, Greenwich, S.E.
1887. §Holt, Thomas. Atlas Iron Works, Molesworth-street, Rochdale.
1875. *Hood, John. The Elms, Cotham Hill, Bristol.
1847. ‡Hooker, Sir Joseph Dalton, K.C.S.I., C.B., M.D., D.C.L., LL.D., F.R.S., F.L.S., F.G.S., F.R.G.S. The Camp, Sunningdale.
1865. *Hooper, John P. Coventry Park, Streatham, London, S.W.
1877. *Hooper, Rev. Samuel F., M.A. The Vicarage, Blackheath Hill, Greenwich, S.E.
1856. ‡Hooton, Jonathan. 80 Great Ducie-street, Manchester.
1842. Hope, Thomas Arthur. 14 Airlie-gardens, Campden Hill, London, W.
1884. *Hopkins, Edward M. 3 Upper Berkeley-street, Portman-square, London, W.
1865. ‡Hopkins, J. S. Jesmond Grove, Edgbaston, Birmingham.
1884. *Hopkinson, Charles. 29 Princess-street, Manchester.
1882. *Hopkinson, Edward, D.Sc. Ireton Bank, Platt-lane, Rusholme, Manchester.
1870. *Hopkinson, John, M.A., D.Sc., F.R.S. Holmwood, Wimbledon, Surrey.
1871. *Hopkinson, John, F.L.S., F.G.S., F.R.Met.Soc. 95 New Bond-street, London, W.; and The Grange, St. Albans.
1858. ‡Hopkinson, Joseph, jun. Britannia Works, Huddersfield.
Hornby, Hugh. Sandown, Liverpool.
1886. ‡Horne, Edward H. Innisfail, Beulah Hill, Norwood, S.E.
1885. ‡Horne, John, F.R.S.E., F.G.S. 41 Southside-road, Inverness.

Year of Election.

1876. *Horne, Robert R. 150 Hope-street, Glasgow.
1875. *Horniman, F. J., F.R.G.S., F.L.S. Surrey Mount, Forest Hill, London, S.E.
1884. *Horsfall, Richard. Stoodley House, Halifax.
1887. ‡Horsfall, T. C. Swanscoe Park, near Macclesfield.
1884. *Hotblach, G. S. Prince of Wales-road, Norwich.
1868. ‡Hotson, W. C. Upper King-street, Norwich.
1859. ‡Hough, Joseph, M.A., F.R.A.S. Codsall Wood, Wolverhampton.
1886. ‡Houghton, F. T. S., M.A. 119 Gough-road, Edgbaston, Birmingham.
1887. ‡Houldsworth, Sir W. H., Bart., M.P. Norbury Booths, Knutsford.
1858. ‡Hounsfield, James. Hemsworth, Pontefract.
1884. ‡Houston, William. Legislative Library, Toronto, Canada.
1883. *Hovenden, Frederick, F.L.S., F.G.S. Glenlea, Thurlow Park-road, West Dulwich, Surrey, S.E.
Hovenden, W. F., M.A. Bath.
1879. *Howard, D. 60 Belsize Park, London, N.W.
1883. ‡Howard, James Fielden, M.D., M.R.C.S. Sandycroft, Shaw.
1886. §Howard, James L., D.Sc. 20 Oxford-road, Waterloo, near Liverpool.
1887. *Howard, S. S. Llanishen Rise, near Cardiff.
1882. ‡Howard, William Frederick, Assoc.M.Inst.C.E. 13 Cavendish-street, Chesterfield, Derbyshire.
1883. ‡Howarth, Richard. York-road, Birkdale, Southport.
1886. ‡Howatt, David. 3 Birmingham-road, Dudley.
1876. ‡Howatt, James. 146 Buchanan-street, Glasgow.
1885. ‡Howden, James C., M.D. Sunnyside, Montrose, N.B.
1889. §Howden, Robert, M.B. Durham College of Medicine, Newcastle-upon-Tyne.
1857. ‡Howell, Henry H., F.G.S., Director of the Geological Survey of Scotland. Geological Survey Office, Victoria-street, Edinburgh.
1887. ‡Howell, J. A. Edward-street, Werneth, Oldham.
1868. ‡Howell, Rev. Canon Hinds. Drayton Rectory, near Norwich.
1886. §Howes, Professor G. B., F.L.S. Science Schools, South Kensington, London, S.W.
1884. ‡Howland, Edward P., M.D. 211 41½-street, Washington, U.S.A.
1884. ‡Howland, Oliver Aiken. Toronto, Canada.
1865. *Howlett, Rev. Frederick, F.R.A.S. East Tisted Rectory, Alton, Hants.
1863. ‡Howorth, H. H., M.P., F.S.A. Bentcliffe, Eccles, Manchester.
1883. ‡Howorth, John, J.P. Springbank, Burnley, Lancashire.
1883. ‡Hoyle, James. Blackburn.
1883. ‡Hoyle, William. Claremont, Bury, Lancashire.
1887. §Hoyle, William E., M.A. 32 Queen-street, Edinburgh.
1888. §Hudd, Alfred E., F.S.A. 94 Pembroke-road, Clifton, Bristol.
1888. ‡Hudson, C. T., M.A., LL.D., F.R.S. 6 Royal York-crescent, Clifton, Bristol.
1867. *Hudson, William H. H., M.A., Professor of Mathematics in King's College, London. 15 Altenberg-gardens, Clapham Common, London, S.W.
1858. *Huggins, William, D.C.L. Oxon., LL.D. Camb., F.R.S., F.R.A.S. 90 Upper Tulse Hill, Brixton, London, S.W.
1857. ‡*Huggon, William.* 30 *Park-row, Leeds.*
1887. ‡Hughes, E. G. 4 Roman-place, Higher Broughton, Manchester.
1883. ‡Hughes, Miss E. P. Newnham College, Cambridge.
1871. *Hughes, George Pringle, J.P. Middleton Hall, Wooler, Northumberland.

Year of Election.

1887. ‡Hughes, John Taylor. Thorleymoor, Ashley-road, Altrincham.
1870. *Hughes, Lewis. Fenwick-court, Liverpool.
1876. *Hughes, Rev. Thomas Edward. Wallfield House, Reigate.
1868. §Hughes, T. M'K., M.A., F.R.S., F.G.S., Woodwardian Professor of Geology in the University of Cambridge.
1865. ‡Hughes, W. R., F.L.S., Treasurer of the Borough of Birmingham. Birmingham.
1883. ‡Hulke, John Whitaker, F.R.S., F.R.C.S., F.G.S. 10 Old Burlington-street, London, W.
1867. §Hull, Edward, M.A., LL.D., F.R.S., F.G.S., Director of the Geological Survey of Ireland and Professor of Geology in the Royal College of Science. 14 Hume-street, Dublin.
*Hulse, Sir Edward, Bart., D.C.L. 47 Portland-place, London, W.; and Breamore House, Salisbury.
1887. *Hummel, Professor J. J. Yorkshire College, Leeds.
1884. *Humphreys, A. W. 45 William-street, New York, U.S.A.
1878. ‡Humphreys, H. Castle-square, Carnarvon.
1880. ‡Humphreys, Noel A., F.S.S. Ravenhurst, Hook, Kingston-on-Thames.
1856. ‡Humphries, David James. 1 Keynsham-parade, Cheltenham.
1862. *Humphry, George Murray, M.D., F.R.S., Professor of Surgery in the University of Cambridge. Grove Lodge, Cambridge.
1877. *Hunt, Arthur Roope, M.A., F.G.S. Southwood, Torquay.
1886. ‡Hunt, Charles. The Gas Works, Windsor-street, Birmingham.
1865. ‡Hunt, J. P. Gospel Oak Works, Tipton.
1884. ‡Hunt, T. Sterry, M.A., D.Sc., LL.D., F.R.S. Park Avenue Hotel, New York, U.S.A.
1864. ‡Hunt, W. Folkestone.
1875. *Hunt, William. Northcote, Westbury-on-Trym, Bristol.
1881. ‡Hunter, F. W. Newbottle, Fence Houses, Co. Durham.
1889. §Hunter, Mrs. F. W. Newbottle, Fence Houses, Co. Durham.
1881. ‡Hunter, Rev. John. University-gardens, Glasgow.
1884. *Hunter, Michael, jun. Greystones, Sheffield.
1869. *Hunter, Rev. Robert. LL.D., F.G.S. Forest Retreat, Staples-road, Loughton, Essex.
1879. ‡Huntington, A. K., F.C.S., Professor of Metallurgy in King's College, London. King's College, London, W.C.
1885. ‡Huntly, The Most Hon. the Marquis of. Aboyne Castle, Aberdeenshire.
1863. ‡Huntsman, Benjamin. West Retford Hall, Retford.
1883. *Hurst, Charles Herbert. Owens College, Manchester.
1869. ‡Hurst, George. Bedford.
1882. ‡Hurst, Walter, B.Sc. West Lodge, Todmorden.
1861. *Hurst, William John. Drumaness Mills, Ballynahinch, Lisburn, Ireland.
1870. ‡Hurter, Dr. Ferdinand. Appleton, Widnes, near Warrington.
Husband, William Dalla. The Roost, Miles-road, Clifton, Bristol.
1887. ‡Husband, W. E. 56 Bury New-road, Manchester.
1882. ‡Hussey, Captain E. R., R.E. 24 Waterloo-place, Southampton.
1876. ‡Hutchinson, John. 22 Hamilton Park-terrace, Glasgow.
1868. *Hutchison, Robert, F.R.S.E. University Club, Princes-street, Edinburgh.
Hutton, Crompton. Harescombe Grange, Stroud, Gloucestershire.
1864. *Hutton, Darnton. 14 Cumberland-terrace, Regent's Park, London. N.W.
1857. ‡Hutton, Henry D. 17 Palmerston-road, Dublin.
1887. §Hutton, J. A. 29 Dale-street, Manchester

Year of Election.

1861. *Hutton, T. Maxwell. Summerhill, Dublin.
1852. ‡Huxley, Thomas Henry, Ph.D., LL.D., D.C.L., F.R.S., F.L.S., F.G.S. 4 Marlborough-place, London, N.W.
Hyde, Edward. Dukinfield, near Manchester.
1883. ‡Hyde, George H. 23 Arbour-street, Southport.
1871. *Hyett, Francis A. Painswick House, Stroud, Gloucestershire.

1882. *I'Anson, James, F.G.S. Fairfield House, Darlington.
Ihne, William, Ph.D. Heidelberg.
1884. §Iles, George. 7 Brunswick-street, Montreal, Canada.
1885. ‡im-Thurn, Everard F. British Guiana.
1888. *Ince, Surgeon-Major John, M.D. Montague House, Swanley, Kent.
1858. ‡Ingham, Henry. Wortley, near Leeds.
1871. ‡Inglis, The Right Hon. John, D.C.L., LL.D., Lord Justice-General of Scotland. Edinburgh.
1876. ‡Inglis, John, jun. Prince's-terrace, Dowanhill, Glasgow.
1852. ‡Ingram, J. K., LL.D., M.R.I.A., Librarian to the University of Dublin. 2 Wellington-road, Dublin.
1885. ‡Ingram, William, M.A. Gamrie, Banff.
1886. ‡Innes, John. The Limes, Alcester-road, Moseley, Birmingham.
1882. §Irving, Rev. A., B.A., B.Sc., F.G.S. Wellington College, Wokingham, Berks.
1888. §Isaac, J. F. V. Freshford House, Freshford, Bath.
1883. ‡Isherwood, James. 18 York-road, Birkdale, Southport.
1881. ‡Ishiguro, Isoji. Care of the Japanese Legation, 9 Cavendish-square, London, W.
1887. §Ito, Tokutaro. 14 Masagochio, Hongo, Tokio, Japan.
1886. ‡Izod, William. Church-road, Edgbaston, Birmingham.

1859. ‡Jack, John, M.A. Belhelvie-by-Whitecairns, Aberdeenshire.
1884. ‡Jack, Peter. People's Bank, Halifax, Nova Scotia, Canada.
1876. *Jack, William, LL.D., Professor of Mathematics in the University of Glasgow. 10 The College, Glasgow.
1883. *Jackson, Professor A. H., B.Sc., F.C.S. Care of Messrs. Wm. Bowen & Co., Collins-street, Melbourne, Australia.
1879. ‡Jackson, Arthur, F.R.C.S. Wilkinson-street, Sheffield.
1883. ‡Jackson, Mrs. Esther. 16 East Park-terrace, Southampton.
1883. ‡Jackson, Frank. 11 Park-crescent, Southport.
1883. *Jackson, F. J. 1 Morley-road, Southport.
1883. ‡Jackson, Mrs. F. J. 1 Morley-road, Southport.
1874. *Jackson, Frederick Arthur. Belmont, Lyme Regis, Dorset.
1886. §Jackson, George. Clareen, Higher Warberry, Torquay.
1887. *Jackson, George. 53 Elizabeth-street, Cheetham, Manchester.
1885. ‡Jackson, Henry. 19 Golden-square, Aberdeen.
1866. ‡Jackson, H. W., F.R.A.S., F.G.S. 67 Upgate, Louth, Lincolnshire.
1869. §Jackson, Moses. The Vale, Ramsgate.
1863. *Jackson-Gwilt, Mrs. H. Moonbeam Villa, The Grove, New Wimbledon, Surrey.
1887. §Jacobson, Nathaniel. Olive Mount, Cheetham Hill-road, Manchester.
1874. *Jaffe, John. Edenvale, Strandtown, near Belfast.
1865 *Jaffray, John. Park-grove, Edgbaston, Birmingham.
1872. ‡James, Christopher. 8 Laurence Pountney-hill, London, E.C.
1860. ‡James, Edward H. Woodside, Plymouth.
1886. ‡James, Frank. Portland House, Aldridge, near Walsall.

Year of Election.

1886. *James, Harry Berkeley, F.R.G.S. 16 Ashburn-place, London, S.W.
1863. *JAMES, Sir WALTER, Bart., F.G.S. 6 Whitehall-gardens, London, S.W.
1858. ‡James, William C. Woodside, Plymouth.
1884. ‡Jameson, W. C. 48 Baker-street, Portman-square, London, W.
1881. ‡Jamieson, Andrew, Principal of the College of Science and Arts, Glasgow.
1887. §Jamieson, G. Auldjo. 3 Drumsheugh-gardens, Edinburgh.
1885. ‡Jamieson, Patrick. Peterhead, N.B.
1885. ‡Jamieson, Thomas. 173 Union-street, Aberdeen.
1859. *Jamieson, Thomas F., F.G.S. Ellon, Aberdeenshire.
1889. *Japp, F. R., M.A., Ph.D., LL.D., F.R.S., For.Sec.C.S., Assistant Professor of Chemistry in the Normal School of Science, South Kensington, London, S.W.
1853. *Jarratt, Rev. Canon J., M.A. North Cave, near Brough, Yorkshire.
1870. ‡Jarrold, John James. London-street, Norwich.
1886. §Jeffcock, Rev. John Thomas. The Rectory, Wolverhampton.
1856. §JEFFERY, HENRY M., M.A., F.R.S. 9 Dunstanville-terrace, Falmouth.
1855. *Jeffray, John. Winton House, Kelvinside, Glasgow.
1883. ‡*Jeffreys, Miss Gwyn. 1 The Terrace, Kensington, London, W.*
1867. ‡Jeffreys, Howel, M.A., F.R.A.S. Pump-court, Temple, London, E.C.
1885. §Jeffreys, Dr. Richard Parker. Eastwood House, Chesterfield.
1887. §Jeffs, Osmund W. 12 Queen's road, Rock Ferry, Cheshire.
1881. ‡JELLICOE, C. W. A. Southampton.
1864. ‡Jelly, Dr. W. Aveleanas, 11, Valencia, Spain.
1873. §Jenkins, Major-General J. J. 16 St. James's-square, London, S.W.
1880. *JENKINS, Sir JOHN JONES. The Grange, Swansea.
1852. ‡Jennings, Francis M., F.G.S., M.R.I.A. Brown-street, Cork.
1872. ‡Jennings, W. 13 Victoria-street, London, S.W.
1878. ‡Jephson, Henry L. Chief Secretary's Office, The Castle, Dublin.
Jessop, William, jun. Overton Hall, Ashover, Chesterfield.
1889. §Jevons, F. B., M.A. The Castle, Durham.
1884. ‡Jewell, Lieutenant Theo. F. Torpedo Station, Newport, Rhode Island, U.S.A.
1884. ‡Johns, Thomas W. Yarmouth, Nova Scotia, Canada.
1884. §Johnson, Alexander, M.A., LL.D., Professor of Mathematics in McGill University, Montreal. 5 Prince of Wales-terrace, Montreal, Canada.
1883. ‡Johnson, Miss Alice. Llandaff House, Cambridge.
1883. ‡Johnson, Ben. Micklegate, York.
1871. *Johnson, David, F.C.S., F.G.S. 52 Fitzjohn's-avenue, South Hampstead, London, N.W.
1881. ‡Johnson, Major E. Cecil. Junior United Service Club, Charles-street, London, S.W.
1883. ‡Johnson, Edmund Litler. 73 Albert-road, Southport.
1865. *Johnson, G. J. 36 Waterloo-street, Birmingham.
1888. §Johnson, J. G. Southwood Court, Highgate, London, N.
1875. ‡Johnson, James Henry, F.G.S. 73 Albert-road, Southport.
1872. ‡Johnson, J. T. 27 Dale-street, Manchester.
1870. ‡Johnson, Richard C., F.R.A.S. 19 Catherine-street, Liverpool.
1863. ‡Johnson, R. S. Hanwell, Fence Houses, Durham.
1881. ‡Johnson, Samuel George. Municipal Offices, Nottingham.
1887. ‡Johnson, W. H. Woodleigh, Altrincham, Cheshire.
1883. ‡Johnson, W. H. F. Llandaff House, Cambridge.

Year of Election.

1883. ‡Johnson, William. Harewood, Roe-lane, Southport.
1861. ‡Johnson, William Beckett. Woodlands Bank, near Altrincham, Cheshire.
1883. ‡Johnston, H. H. Tudor House, Champion Hill, London, S.E.
1859. ‡Johnston, James. Newmill, Elgin, N.B.
1864. ‡Johnston, James. Manor House, Northend, Hampstead, London, N.W.
1884. ‡Johnston, John L. 27 St. Peter-street, Montreal, Canada.
1883. ‡Johnston, Thomas. Broomsleigh, Seal, Sevenoaks.
1884. ‡Johnston, Walter R. Fort Qu'Appelle, N.W. Territory, Canada.
1884. *Johnston, W. H. 6 Latham-street, Preston, Lancashire.
1885. ‡Johnston-Lavis, H. J., M.D., F.G.S. Palazzo Caramanico, Chiatomone, Naples.
1886. ‡Johnstone, G. H. Northampton-street, Birmingham.
1864. *Johnstone, James. Alva House, Alva, by Stirling, N.B.
1876. ‡Johnstone, William. 5 Woodside-terrace, Glasgow.
1864. ‡Jolly, Thomas. Park View-villas, Bath.
1871. ‡JOLLY, WILLIAM, F.R.S.E., F.G.S., H.M. Inspector of Schools. St. Andrew's-road, Pollokshields, Glasgow.
1888. ‡Jolly, W. C. Home Lea, Lansdowne, Bath.
1888. ‡Joly, John. 39 Waterloo-road, Dublin.
1881. ‡Jones, Alfred Orlando, M.D. Cardigan Villa, Harrogate.
1849. ‡Jones, Baynham. Walmer House, Cheltenham.
1887. ‡Jones, D. E., B.Sc. University College, Aberystwith.
1887. ‡Jones, Francis. Beaufort House, Alexandra Park, Manchester.
1883. *Jones, George Oliver, M.A. 5 Cook-street, Liverpool.
1884. ‡Jones, Rev. Harry, M.A. 8 York-gate, Regent's Park, London, N.W.
1877. ‡Jones, Henry C., F.C.S. Normal School of Science, South Kensington, London, S.W.
1883. ‡Jones, Rev. Canon Herbert. Waterloo, Liverpool.
1881. *JONES, J. VIRIAMU, M.A., B.Sc., Principal of the University College of South Wales and Monmouthshire. Cardiff.
1873. ‡Jones, Theodore B. 1 Finsbury-circus, London, E.C.
1880. ‡Jones, Thomas. 15 Gower-street, Swansea.
1860. ‡JONES, THOMAS RUPERT, F.R.S., F.G.S. 10 Uverdale-road, King's-road, Chelsea, London, S.W.
1883. ‡Jones, William. Elsinore, Birkdale, Southport.
1875. *Jose, J. E. 11 Cressington Park, Liverpool.
1884. ‡Joseph, J. H. 738 Dorchester-street, Montreal, Canada.
1875. *Joule, Benjamin St. John B., J.P. Rothesay, N.B.
1847. ‡JOWETT, Rev. B., M.A., Regius Professor of Greek in the University of Oxford. Balliol College, Oxford.
1879. ‡Jowitt, A. Hawthorn Lodge, Clarkehouse-road Sheffield.
1872. ‡Joy, Algernon. Junior United Service Club, St. James's, London, S.W.
1848. *Joy, Rev. Charles Ashfield. West Hanney, Wantage, Berkshire.
1883. ‡Joyce, Rev. A. G., B.A. St. John's Croft, Winchester.
1886. ‡Joyce, The Hon. Mrs. St. John's Croft, Winchester.
1848. *Jubb, Abraham. Halifax.
1870. ‡JUDD, JOHN WESLEY, F.R.S., F.G.S., Professor of Geology in the Royal School of Mines. 31 Ennerdale-road, Kew.
1883. ‡Justice, Philip M. 14 Southampton-buildings, Chancery-lane, London, W.C.

1868. *Kaines, Joseph, M.A., D.Sc. 8 Osborne-road, Stroud Green-road, London, N.

Year of Election.

1888. §Kapp, Gisbert. Stanley Villa, Wimbledon, Surrey.
1887. ‡Kay, Miss. Hamerlaund, Broughton Park, Manchester.
1859. ‡Kay, David, F.R.G.S. 19 Upper Phillimore-place, Kensington, London, W.
Kay, John Cunliff. Fairfield Hall, near Skipton.
1883. ‡Kearne, John H. Westcliffe-road, Birkdale, Southport.
1884. ‡Keefer, Samuel. Brockville, Ontario, Canada.
1884. ‡Keefer, Thomas Alexander. Port Arthur, Ontario, Canada.
1875. ‡Keeling, George William. Tuthill, Lydney.
1886. ‡Keen, Arthur, J.P. Sandyford, Augustus-road, Birmingham.
1878. **Kelland, William Henry. Grettans, Bow, North Devon.*
1887. ‡Kellas-Johnstone, J. F. 69 Princess-street, Manchester.
1884. ‡Kellogg, J. H., M D. Battle Creek, Michigan, U.S.A.
1864. *Kelly, W. M., M.D. 11 The Crescent, Taunton, Somerset.
1885. §Keltie, J. Scott, Librarian R.G.S. 1 Savile-row, London, W.
1887. §Kemp, Harry. 254 Stretford-road, Manchester.
1884. §Kemper, Andrew C., A.M., M.D. 101 Broadway, Cincinnati, U.S.A.
1875. ‡KENNEDY, ALEXANDER B. W., F.R.S., M.Inst.C.E., Emeritus Professor of Engineering in University College, London. Lawn House, Hampstead-square, London, N.W.
1884. ‡Kennedy, George L., M.A., F.G.S., Professor of Chemistry and Geology in King's College, Windsor, Nova Scotia, Canada.
1876. ‡Kennedy, Hugh. Redclyffe, Partickhill, Glasgow.
1884. ‡Kennedy, John. 113 University-street, Montreal, Canada.
1884. ‡Kennedy, William. Hamilton, Ontario, Canada.
1886. ‡Kenrick, George Hamilton. Whetstone, Somerset-road, Edgbaston, Birmingham.
Kent, J. C. Levant Lodge, Earl's Croome, Worcester.
1886. §Kenward, James, F.S.A. 280 Hagley-road, Birmingham.
1857. *Ker, André Allen Murray. Newbliss House, Newbliss, Ireland.
1876. ‡Ker, William. 1 Windsor-terrace West, Glasgow.
1881. ‡Kermode, Philip M. C. Ramsay, Isle of Man.
1884. ‡Kerr, James, M.D. Winnipeg, Canada.
1887. ‡Kerr, James. Dunkenhalgh, Accrington.
1883. ‡Kerr, Dr. John. Garscadden House, near Kilpatrick, Glasgow.
1889. §Kerry, W. H. R. Manor House, Liscard, Cheshire.
1887. §Kershaw, James. Holly House, Bury New-road, Manchester.
1869. *Kesselmeyer, Charles A. Villa 'Mon Repos,' Altrincham, Cheshire.
1869. *Kesselmeyer, William Johannes. Villa 'Mon Repos,' Altrincham, Cheshire.
1883. *Keynes, J. N., M.A., B.Sc., F.S.S. 6 Harvey-road, Cambridge.
1876. ‡Kidston, J. B. 50 West Regent-street, Glasgow.
1886. §KIDSTON, ROBERT, F.R.S.E., F G.S. 24 Victoria-place, Stirling.
1885. *Kilgour, Alexander. Loirston House, Cove, near Aberdeen.
1865. *Kinahan, Sir Edward Hudson, Bart., M.R.I.A. 11 Merrion-square North, Dublin.
1878. ‡Kinahan, Edward Hudson, jun. 11 Merrion-square North, Dublin.
1860. ‡KINAHAN, G. HENRY, M.R.I.A. Geological Survey of Ireland, 14 Hume-street, Dublin.
1875. *KINCH, EDWARD, F.C.S. Royal Agricultural College, Cirencester.
1888. ‡King, Austin J. Winsley Hill, Limpley Stoke, Bath.
1888. *King, E. Powell. Wainsford, Lymington, Hants.
1883. *King, Francis. Alabama, Penrith.
1875. *King, F. Ambrose. Avonside, Clifton, Bristol.
1871. *King, Rev. Herbert Poole. The Rectory, Stourton, Bath.

Year of Election.

1855. †King, James. Levernholme, Hurlet, Glasgow.
1883. *King, John Godwin. Wainsford, Lymington, Hants.
1870. †King, John Thomson. 4 Clayton-square, Liverpool.
King, Joseph. Welford House, Greenhill, Hampstead, London, N.W.
1883. *King, Joseph, jun. 44 Well-walk, Hampstead, London, N.W.
1860. *King, Mervyn Kersteman. 1 Vittoria-square, Clifton, Bristol.
1875. *King, Percy L. Avonside, Clifton, Bristol.
1888. ‡King, Richard. Grosvenor Lodge, Bath.
1870. ‡King, William. 5 Beach Lawn, Waterloo, Liverpool.
1889. §King, Sir William. Lynwood, Waverley-road, Southsea.
1869. ‡Kingdon, K. Taddiford, Exeter.
1861. ‡Kingsley, John. Ashfield, Victoria Park, Manchester.
1876. §Kingston, Thomas. The Limes, Clewer, near Windsor.
1875. §Kingzett, Charles T., F.C.S. Trevena, Amhurst Park, London, N.
1867. ‡Kinloch, Colonel. Kirriemuir, Logie, Scotland.
1870. ‡Kinsman, William R. Branch Bank of England, Liverpool.
1860. ‡Kirkman, Rev. Thomas P., M.A., F.R.S. Croft Rectory, near Warrington.
1875. ‡Kirsop, John. 6 Queen's-crescent, Glasgow.
1883. ‡Kirsop, Mrs. 6 Queen's-crescent, Glasgow.
1870. ‡Kitchener, Frank E. Newcastle, Staffordshire.
1890. *Kitson, Sir James, Bart. Gledhow Hall, Leeds.
1886. ‡Klein, Rev. L. Martial. University College, Dublin.
1869. ‡Knapman, Edward. The Vineyard, Castle-street, Exeter.
1886. §Knight, J. M. Bushwood, Wanstead, Essex.
1883. ‡Knight, J. R. 32 Lincoln's Inn-fields, London, W.C.
1888. ‡Knott, Cargill G., D.Sc., F.R.S.E. Tokio, Japan.
1872. *Knott, George, LL.B., F.R.A.S. Knowles Lodge, Cuckfield, Hayward's Heath, Sussex.
1887. *Knott, Herbert. Wharf Street Mills, Ashton-under-Lyne.
1887. *Knott, John F. Staveleigh, Stalybridge, Cheshire.
1887. ‡Knott, Mrs. Staveleigh, Stalybridge, Cheshire.
1887. §Knott, T. B. Ellerslie, Cheadle, Hulme, Cheshire.
1873. *Knowles, George. Moorhead, Shipley, Yorkshire.
1872. ‡Knowles, James. The Hollies, Clapham Common, S.W.
1870. ‡Knowles, Rev. J. L. 103 Earl's Court-road, Kensington, London, W.
1874. ‡Knowles, William James. Flixton-place, Ballymena, Co. Antrim.
1883. ‡Knowlys, Rev. C. Hesketh. The Rectory, Roe-lane, Southport.
1883. ‡Knowlys, Mrs. C. Hesketh. The Rectory, Roe-lane, Southport.
1876. ‡Knox, David N., M.A., M.B. 24 Elmbank-crescent, Glasgow.
*Knox, George James. 29 Portland-terrace, Regent's Park, London, N.W.
1875. *Knubley, Rev. E. P. Staveley Rectory, Leeds.
1883. ‡Knubley, Mrs. Staveley Rectory, Leeds.
1888. *Kunz, G. F. Care of Messrs. Tiffany & Co., Union-square, New York City, U.S.A.
1881. ‡Kurobe, Hiroo. Legation of Japan, 9 Cavendish-square, London, W.
1870. ‡Kynaston, Josiah W., F.C.S. Kensington, Liverpool.
1865. ‡Kynnersley, J. C. S. The Leveretts, Handsworth, Birmingham.

1858. ‡Lace, Francis John. Stone Gapp, Cross-hill, Leeds.
1884. ‡Laflamme, Rev. Professor J. C. K. Laval University, Quebec, Canada.
1885. *Laing, J. Gerard. 1 Elm-court, Temple, London, E.C.
1870. ‡Laird, H. H. Birkenhead.

Year of Election.

1870. §Laird, John. Grosvenor-road, Claughton, Birkenhead.
1882. ‡Lake, G. A. K., M.D. East Park-terrace, Southampton.
1880. ‡*Lake, Samuel. Milford Docks, Milford Haven.*
1877. ‡Lake, W. C., M.D. Teignmouth.
1859. ‡Lalor, John Joseph, M.R.I.A. City Hall, Cork Hill, Dublin.
1889. *Lamb, Edmund. Union Club, Trafalgar-square, London, S.W.
1887. ‡Lamb, Horace, M.A., F.R.S., Professor of Pure Mathematics in the Owens College, Manchester. Manchester.
1887. ‡Lamb, James. Kenwood, Bowdon, Cheshire.
1883. ‡Lamb, W. J. 11 Gloucester-road, Birkdale, Southport.
1883. ‡LAMBERT, Rev. BROOKE, LL.B. The Vicarage, Greenwich, Kent, S.E.
1884. ‡Lamborn, Robert H. Montreal, Canada.
1884. ‡Lancaster, Alfred. Fern Bank, Burnley, Lancashire.
1871. ‡Lancaster, Edward. Karesforth Hall, Barnsley, Yorkshire.
1886. ‡Lancaster, W. J., F.G.S. Colmore-row, Birmingham.
1877. ‡Landon, Frederic George, M.A., F.R.A.S. 59 Tresillian-road, St. John's, S.E.
1883. ‡Lang, Rev. Gavin. Inverness.
1859. ‡Lang, Rev. John Marshall, D.D. Barony, Glasgow.
1886. *LANGLEY, J. N., M.A., F.R.S. Trinity College, Cambridge.
1870. ‡Langton, Charles. Barkhill, Aigburth, Liverpool.
1865. ‡LANKESTER, E. RAY, M.A., LL.D., F.R.S., Professor of Comparative Anatomy and Zoology in University College, London. 42 Half Moon-street, Piccadilly, London, W.
1880. *LANSDELL, Rev. HENRY, D.D., F.R.A.S., F.R.G.S. Care of Mr. Wheldon, 58 Great Queen-street, Lincoln's Inn-fields, London, W.C.
1884. ‡Lanza, Professor G. Massachusetts Institute of Technology, Boston, U.S.A.
1878. ‡Lapper, E., M.D. 61 Harcourt-street, Dublin.
1886. ‡*Lapraik, W. 9 Malfort-road, Denmark Hill, London, S.E.*
1885. ‡LAPWORTH, CHARLES, LL.D., F.R.S., F.G.S., Professor of Geology and Mineralogy in the Mason Science College, Birmingham. 13 Duchess-road, Edgbaston, Birmingham.
1887. ‡Larmor, Alexander. Clare College, Cambridge.
1881. ‡Larmor, Joseph, M.A., Professor of Natural Philosophy in Queen's College, Galway.
1883. §Lascelles, B. P. Harrow.
1870. *LATHAM, BALDWIN, M.Inst.C.E., F.G.S. 7 Westminster-chambers, Westminster, S.W.
1870. ‡LAUGHTON, JOHN KNOX, M.A., F.R.G.S. 130 Sinclair-road, West Kensington Park, London, W.
1888. ‡LAURIE, Colonel R. P., C.B., M.P. 35 Eaton-place, London, S.W.
1883. ‡Laurie, Major-General. Oakfield, Nova Scotia.
1870. *Law, Channell. Ilsham Dene, Torquay.
1878. ‡Law, Henry, M.Inst.C.E. 9 Victoria-chambers, London, S.W.
1862. ‡Law, Rev. James Edmund, M.A. Little Shelford, Cambridgeshire.
1884. §Law, Robert. 11 Cromwell-terrace, West Hill Park, Halifax, Yorkshire.
1870. ‡Lawrence, Edward. Aigburth, Liverpool.
1881. ‡Lawrence, Rev. F., B.A. The Vicarage, Westow, York.
1889. §Laws, W. G. 5 Winchester-terrace, Newcastle-upon-Tyne.
1875. ‡Lawson, George, Ph.D., LL.D., Professor of Chemistry and Botany. Halifax, Nova Scotia.
1885. ‡Lawson, James. 8 Church-street, Huntly, N.B.
1868. *Lawson, M. Alexander, M.A., F.L.S. Ootâcamund, Bombay.

Year of Election.

1853. †Lawton, William. 5 Victoria-terrace, Derringham, Hull.
1888. †Layard, Miss Nina F. Turleigh House, near Bradford-on-Avon.
1856. ‡Lea, Henry. 38 Bennett's-hill, Birmingham.
1883. *Leach, Charles Catterall. Seghill, Northumberland.
1883. §Leach, John. Haverhill House, Bolton.
1875. ‡Leach, Colonel R. E. Mountjoy, Phœnix Park, Dublin.
1870. *Leaf, Charles John, F.L.S., F.G.S., F.S.A. 6 Sussex-place, Regent's Park, London, N.W.
1884. *Leahy, John White, J.P. South Hill, Killarney, Ireland.
1884. ‡Learmont, Joseph B. 120 Mackay-street, Montreal, Canada.
1847. *Leatham, Edward Aldam, M.P. Whitley Hall, Huddersfield; and 46 Eaton-square, London, S.W.
1863. ‡Leavers, J. W. The Park, Nottingham.
1884. *Leavitt, Erasmus Darwin. 604 Main-street, Cambridgeport, Massachusetts, U.S.A.
1872. ‡Lebour, G. A., M.A., F.G.S., Professor of Geology in the College of Physical Science, Newcastle-on-Tyne.
1884. ‡Leckie, R. G. Springhill, Cumberland County, Nova Scotia.
1883. ‡Lee, Daniel W. Halton Bank, Pendleton, near Manchester.
1861. ‡Lee, Henry, M.P. Sedgeley Park, Manchester.
1883. ‡Lee, J. H. Warburton. Rossall, Fleetwood.
1887. *Lee, Sir Joseph Cooksey. Park Gate, Altrincham.
1884. *Leech, Bosdin T. Oak Mount, Timperley, Cheshire.
1887. ‡Leech, D. J. Elm House, Whalley Range, Manchester.
1886. *Lees, Lawrence W. Claregate, Tettenhall, Wolverhampton.
1882. ‡Lees, R. W. Moira-place, Southampton.
1859. ‡Lees, William, M.A. St. Leonard's, Morningside-place, Edinburgh.
1883. *Leese, Miss H. K. Fylde-road Mills, Preston, Lancashire.
*Leese, Joseph. Fylde-road Mills, Preston, Lancashire.
1883. ‡Leese, Mrs. Hazeldene, Fallowfield, Manchester.
1889. *Leeson, John Rudd, M.D., F.G.S. Clifden House, Twickenham, Middlesex.
1881. ‡Le Feuvre, J. E. Southampton.
1872. ‡Lefevre, The Right Hon. G. Shaw, M.P., F.R.G.S. 18 Bryanston square, London, W.
*Lefroy, General Sir John Henry, R.A., K.C.M.G., C.B., LL.D., F.R.S., F.R.G.S. 82 Queen's-gate, London, S.W.
*Legh, Lieut.-Colonel George Cornwall. High Legh Hall, Cheshire.
1869. ‡Le Grice, A. J. Trereife, Penzance.
1868. ‡Leicester, The Right Hon. the Earl of, K.G. Holkham, Norfolk.
1861. *Leigh, Henry. Moorfield, Swinton, near Manchester.
1856. ‡Leigh, The Right Hon. Lord, D.C.L. 37 Portman-square, London, W.; and Stoneleigh Abbey, Kenilworth.
1886. §Leipner, Adolph, Professor of Botany in University College, Bristol. 47 Hampton Park, Bristol.
1867. ‡Leishman, James. Gateacre Hall, Liverpool.
1859. ‡Leith, Alexander. Glenkindie, Inverkindie, N.B.
1882. §Lemon, James, M.Inst.C.E. 11 The Avenue, Southampton.
1863. *Lendy, Major Auguste Frederic, F.L.S., F.G.S. Sunbury House, Sunbury, Middlesex.
1867. ‡Leng, John. 'Advertiser' Office, Dundee.
1878. ‡Lennon, Rev. Francis. The College, Maynooth, Ireland.
Lentaigne, Joseph. 12 Great Denmark-street, Dublin.
1887. *Leon, John T. 38 Portland-place, London, W.
1871. ‡Leonard, Hugh, F.G.S., M.R.I.A., F.R.G.S.I. St. David's, Malahide-road, Co. Dublin.

Year of
Election.

1874. ‡Lepper, Charles W. Laurel Lodge, Belfast.
1884. ‡Lesage, Louis. City Hall, Montreal, Canada.
1871. ‡Leslie, Alexander, M.Inst.C.E. 72 George-street, Edinburgh.
1883. §Lester, Thomas. Fir Bank, Penrith.
1880. ‡LETCHER, R. J. Lansdowne-terrace, Walters-road, Swansea.
1887. ‡Leverkus, Otto. The Downs, Prestwich, Manchester.
1887. **Levinstein, Ivan. Villa Newberg, Victoria Park, Manchester.*
1879. ‡Lewin, Colonel, F.R.G.S. Garden Corner House, Chelsea Embankment, London, S.W.
1870. ‡LEWIS, ALFRED LIONEL. 54 Highbury-hill, London, N.
1884. *Lewis, Sir W. T. The Mardy, Aberdare.
1853. ‡Liddell, George William Moore. Sutton House, near Hull.
1860. ‡LIDDELL, The Very Rev. H. G., D.D., Dean of Christ Church, Oxford.
1887. ‡Liebermann, L. 54 Portland-street, Manchester.
1876. ‡Lietke, J. O. 30 Gordon-street, Glasgow.
1887. *Lightbown, Henry. Weaste Hall, Pendleton, Manchester.
1862. ‡LILFORD, The Right Hon. Lord, F.L.S. Lilford Hall, Oundle, Northamptonshire.
*LIMERICK, The Right Rev. CHARLES GRAVES, Lord Bishop of, D.D., F.R.S., M.R.I.A. The Palace, Henry-street, Limerick.
1887. ‡Limpach, Dr. Crumpsall Vale Chemical Works, Manchester.
1878. ‡Lincolne, William. Ely, Cambridgeshire.
1881. *Lindley, William, M.Inst.C.E., F.G.S. 74 Shooters Hill-road, Blackheath, London, S.E.
1870. ‡Lindsay, Thomas, F.C.S. Maryfield College, Maryhill, by Glasgow.
1871. ‡Lindsay, Rev. T. M., M.A., D.D. Free Church College, Glasgow.
1876. ‡Linn, James. Geological Survey Office, India-buildings, Edinburgh.
1883. §Lipscomb, Mrs. Lancelot C. d'A. 95 Elgin-crescent, London, W.
1883. ‡Lisle, H. Claud. Nantwich.
1882. *Lister, Rev. Henry, M.A. Hawridge Rectory, Berkhampstead.
1888. §Lister, J. J. Leytonstone, Essex, E.
1876. ‡Little, Thomas Evelyn. 42 Brunswick-street, Dublin.
Littledale, Harold. Liscard Hall, Cheshire.
1881. ‡*Littlewood, Rev. B. C., M.A. Holmdale, Cheltenham.*
1861. *LIVEING, G. D., M.A., F.R.S., F.C.S., Professor of Chemistry in the University of Cambridge. Newnham, Cambridge.
1876. *Liversidge, Archibald, F.R.S., F.C.S., F.G.S., F.R.G.S., Professor of Chemistry and Mineralogy in the University of Sydney, N.S.W. Care of Messrs. Trübner & Co., Ludgate Hill, London, E.C.
1864. §Livesay, J. G. Cromartie House, Ventnor, Isle of Wight.
1880. ‡Llewelyn, John T. D. Penllegare, Swansea.
Lloyd, Rev. A. R. Hengold, near Oswestry.
1889. §Lloyd, Rev. Canon. The Vicarage, Rye Hill, Newcastle-upon-Tyne.
1842. Lloyd, Edward. King-street, Manchester.
1865. ‡Lloyd, G. B., J.P. Edgbaston-grove, Birmingham.
*Lloyd, George, M.D., F.G.S. Bryntirion, Berkhamsted, Herts.
1865. ‡Lloyd, John. Queen's College, Birmingham.
1886. ‡Lloyd, John Henry. Ferndale, Carpenter-road, Edgbaston, Birmingham.
1886. ‡Lloyd, Samuel. Farm, Sparkbrook, Birmingham.
1865. *Lloyd, Wilson, F.R.G.S. Myvod House, Wednesbury.
1854. *LOBLEY, JAMES LOGAN, F.G.S., F.R.G.S. City of London College, Moorgate-street, London, E.C.
1867. *Locke, John. Whitehall Club, London, S.W.

Year of Election.

1863. ‡LOCKYER, J. NORMAN, F.R.S., F.R.A.S. Science Schools, South Kensington, London, S.W.
1886. *Lodge, Alfred, M.A. Cooper's Hill, Staines.
1875. *LODGE, OLIVER J., D.Sc., LL.D., F.R.S., Professor of Physics in University College, Liverpool. 21 Waverley-road, Sefton Park, Liverpool.
1889. §Logan, William. Langley Park, Durham.
1883. ‡*London, Rev. H. High Lee, Knutsford.*
1876. ‡Long, H. A. Charlotte-street, Glasgow.
1871. *Long, John Jex. 11 Doune-terrace, Kelvinside, Glasgow.
1851. ‡Long, William, F.G.S. Hurts Hall, Saxmundham, Suffolk.
1883. *Long, William. Thelwall Heys, near Warrington.
1883. ‡Long, Mrs. Thelwall Heys, near Warrington.
1883. ‡Long, Miss. Thelwall Heys, near Warrington.
1866. ‡Longdon, Frederick. Osmaston-road, Derby.
1883. ‡Longe, Francis D. Coddenham Lodge, Cheltenham.
1883. ‡Longmaid, William Henry. 4 Rawlinson-road, Southport.
1875. *Longstaff, George Blundell, M.A., M.B., F.C.S., F.S.S. Southfield Grange, Wandsworth, S.W.
1871. §Longstaff, George Dixon, M.D., F.C.S. Butterknowle, Wandsworth, S.W.
1872. *Longstaff, Llewellyn Wood, F.R.G.S. Ridgelands, Wimbledon, Surrey.
1881. *Longstaff, Mrs. Ll. W. Ridgelands, Wimbledon, Surrey.
1883. *Longton, E. J., M.D. Lord-street, Southport.
1861. *Lord, Edward. Adamroyd, Todmorden.
1889. §Lord, Riley. Highfield House, Gosforth, Newcastle-upon-Tyne.
1863. ‡Losh, W. S. Wreay Syke, Carlisle.
1883. *Louis, D. A., F.C.S. 77 Shirland-gardens, London, W.
1887. *Love, A. E. H. St. John's College, Cambridge.
1886. *Love, E. F. J., M.A. The University, Melbourne, Australia.
1876. *Love, James, F.R.A.S., F.G.S., F.Z.S. 11 Notting Hill-square, London, W.
1883. §Love, James Allen. 8 Eastbourne-road West, Southport.
1875. *Lovett, W. Jesse, F.I.C. Lawefield-lane, Wakefield.
1889. §Low, Charles W. 84 Westbourne-terrace, London, W.
1867. *Low, James F. Monifieth, by Dundee.
1885. §Lowdell, Sydney Poole. Baldwyn's Hill, East Grinstead, Sussex.
1885. *Lowe, Arthur C. W. Gosfield Hall, Halstead, Essex.
1861. *LOWE, EDWARD JOSEPH, F.R.S., F.R.A.S., F.L.S., F.G.S., F.R.M.S. Shirenewton Hall, near Chepstow.
1884. ‡Lowe, F. J. Elm-court, Temple, London, E.C.
1886. *Lowe, John Landor, M.Inst.C.E. 113 St. Pancras-road, London, N.W.
1850. ‡Lowe, William Henry, M.D., F.R.S.E. Balgreen, Slateford, Edinburgh.
1881. ‡Lubbock, Arthur Rolfe. High Elms, Hayes, Kent.
1853. *LUBBOCK, The Right Hon. Sir JOHN, Bart., M.P., D.C.L., LL.D., F.R.S., F.L.S., F.G.S. Down, Farnborough, Kent.
1881. ‡Lubbock, John B. High Elms, Hayes, Kent.
1870. ‡Lubbock, Montague, M.D. 19 Grosvenor-street, London, W.
1889. §Lucas, John. 1 Carlton-terrace, Low Fell, Gateshead.
1878. ‡Lucas, Joseph. Tooting Graveney, London, S.W.
1849. *Luckcock, Howard. Oak-hill, Edgbaston, Birmingham.
1889. §Luckley, George. 7 Victoria-square, Newcastle-upon-Tyne.
1875. ‡Lucy, W. C., F.G.S. The Winstones, Brookthorpe, Gloucester.
1881. ‡Luden, C. M. 4 Bootham-terrace, York.

Year of Election.

1873. ‡Lumley, J. Hope Villa, Thornbury, near Bradford, Yorkshire.
1885. ‡*Lumsden, Robert. Ferryhill House, Aberdeen.*
1866. *Lund, Charles. Ilkley, Yorkshire.
1873. ‡Lund, Joseph. Ilkley, Yorkshire.
1850. *Lundie, Cornelius. 321 Newport-road, Cardiff.
1853. ‡Lunn, William Joseph, M.D. 23 Charlotte-street, Hull.
1883. *Lupton, Arnold, M.Inst.C.E., F.G.S., Professor of Mining Engineering in Yorkshire College. 6 De Grey-road, Leeds.
1874. *Lupton, Sydney, M.A. Grove Cottage, Roundhay, near Leeds.
1864. *Lutley, John. Brockhampton Park, Worcester.
1871. ‡Lyell, Leonard, F.G.S. 92 Onslow-gardens, London, S.W.
1884. ‡Lyman, A. Clarence. 84 Victoria-street, Montreal, Canada.
1884. ‡Lyman, H. H. 74 McTavish-street, Montreal, Canada.
1884. ‡Lyman, Roswell C. 74 McTavish-street, Montreal, Canada.
1874. ‡Lynam, James. Ballinasloe, Ireland.
1885. §Lyon, Alexander, jun. 52 Carden-place, Aberdeen.
1857. ‡*Lyons, Robert D., M.B., M.R.I.A. 8 Merrion-square West, Dublin.*
1878. ‡Lyte, Cecil Maxwell. Cotford, Oakhill-road, Putney, S.W.
1862. *Lyte, F. Maxwell, F.C.S. 60 Finborough-road, London, S.W.

1852. ‡McAdam, Robert. 18 College-square East, Belfast.
1854. *Macadam, Stevenson, Ph.D., F.R.S.E., F.C.S., Lecturer on Chemistry. Surgeons' Hall, Edinburgh; and Brighton House, Portobello, by Edinburgh.
1876. *Macadam, William Ivison. Surgeons' Hall, Edinburgh.
1868. ‡Macalister, Alexander, M.D., F.R.S., Professor of Anatomy in the University of Cambridge. Torrisdale, Cambridge.
1889. §McAllum, John. The Willows, Clayton Park-road, Jesmond, Newcastle-upon-Tyne.
1878. ‡MacAlister, Donald, M.A., M.D., B.Sc. St. John's College, Cambridge.
1879. §MacAndrew, James J. Lukesland, Ivybridge, South Devon.
1883. §MacAndrew, Mrs. J. J. Lukesland, Ivybridge, South Devon.
1883. §MacAndrew, William. Westwood House, near Colchester.
1866. *M'Arthur, Alexander, M.P., F.R.G.S. 79 Holland Park, London, W.
1884. ‡Macarthur, Alexander. Winnipeg, Canada.
1884. ‡Macarthur, D. Winnipeg, Canada.
1834. Macaulay, James, A.M., M.D. 25 Carlton-road, Maida Vale, London, N.W.
1840. *MacBrayne, Robert. Care of Messrs. Black & Wingate, 5 Exchange-square, Glasgow.
1884. ‡McCabe, T., Chief Examiner of Patents. Patent Office, Ottawa, Canada.
1855. ‡*M'Cann, Rev. James, D.D., F.G.S. The Lawn, Lower Norwood, Surrey, S.E.*
1886. ‡MacCarthy, Rev. E. F. M., M.A. 93 Hagley-road, Birmingham.
1887. *McCarthy, James. Bangkok, Siam.
1884. *McCarthy, J. J., M.D. Junior Army and Navy Club, London, S.W.
1884. ‡McCausland, Orr. Belfast.
1876. *M'Clelland, A. S. 4 Crown-gardens, Dowanhill, Glasgow.
1868. ‡M'Clintock, Admiral Sir Francis L., R.N., F.R.S., F.R.G.S. United Service Club, Pall Mall, London, S.W.
1872. **M'Clure, J. H., F.R.G.S. Chavoire Annecy, Haute Savoie, France.*
1874. ‡M'Clure, Sir Thomas, Bart. Belmont, Belfast.
1878. *M'Comas, Henry. Homestead, Dundrum, Co. Dublin.

Year of Election.

1858. ‡M'Connell, J. E. Woodlands, Great Missenden.
1883. ‡McCrossan, James. 92 Huskisson-street, Liverpool.
1876. ‡*M'Culloch, Richard. 109 Douglas-street, Blythswood-square, Glasgow.*
1884. ‡MACDONALD, The Right Hon. Sir JOHN ALEXANDER, G.C.B., D.C.L., LL.D. Ottawa, Canada.
1886. §McDonald, John Allen. 6 Holly-place, Hampstead, London, N.W.
1884. ‡MacDonald, Kenneth. Town Hall, Inverness.
1884. *McDonald, W. C. 891 Sherbrooke-street, Montreal, Canada.
1878. ‡McDonnell, Alexander. St. John's, Island Bridge, Dublin.
1884. ‡MacDonnell, Mrs. F. H. 1433 St. Catherine-street, Montreal, Canada.
MacDonnell, Hercules H. G. 2 Kildare-place, Dublin.
1883. ‡MacDonnell, Rev. Canon J. C., D.D. Misterton Rectory, Lutterworth.
1878. ‡McDonnell, James. 32 Upper Fitzwilliam-street, Dublin.
1884. ‡Macdougall, Alan. Toronto, Canada.
1884. ‡McDougall, John. 35 St. François Xavier-street, Montreal, Canada.
1881. ‡Macfarlane, Alexander, D.Sc., F.R.S.E., Professor of Physics in the University of Texas. Austin, Texas, U.S.A.
1871. ‡M'Farlane, Donald. The College Laboratory, Glasgow.
1885. ‡Macfarlane, J. M., D.Sc. 3 Bellevue-terrace, Edinburgh.
1879. ‡Macfarlane, Walter, jun. 12 Lynedoch-crescent, Glasgow.
1884. ‡Macfie, K. N., B.A., B.C.L. Winnipeg, Canada.
1854. *Macfie, Robert Andrew. Dreghorn, Colinton, Edinburgh.
1867. *M'Gavin, Robert. Ballumbie, Dundee.
1855. ‡*MacGeorge, Andrew, jun. 21 St. Vincent-place, Glasgow.*
1888. §MacGeorge, James. 1 Devonshire-terrace, Kensington, London, W.
1884. ‡MacGillivray, James. 42 Cathcart-street, Montreal, Canada.
1884. ‡MacGoun, Archibald, jun., B.A., B.C.L. 19 Place d'Armes, Montreal, Canada.
1873. ‡McGowen, William Thomas. Oak-avenue, Oak Mount, Bradford, Yorkshire.
1885. ‡Macgregor, Alexander, M.D. 256 Union-street, Aberdeen.
1884. *MACGREGOR, JAMES GORDON, M.A., D.Sc., F.R.S.E., Professor of Physics in Dalhousie College, Halifax, Nova Scotia, Canada.
1886. ‡McGregor, William. Kohima Lodge, Bedford.
1885. ‡M'Gregor-Robertson, J., M.A., M.B. 400 Great Western-road, Glasgow.
1876. ‡M'Grigor, Alexander B., LL.D. 19 Woodside-terrace, Glasgow.
1867. *M'INTOSH, W. C., M.D., LL.D., F.R.S. L. & E., F.L.S., Professor of Natural History in the University of St. Andrews. 2 Abbotsford-crescent, St. Andrews, N.B.
1884. ‡McIntyre, John, M.D. Odiham, Hants.
1883. ‡Mack, Isaac A. Trinity-road, Bootle.
1884. ‡Mackay, Alexander Howard, B.A., B.Sc. The Academy, Pictou, Nova Scotia, Canada.
1885. §MACKAY, JOHN YULE, M.D. The University, Glasgow.
1873. ‡MCKENDRICK, JOHN G., M.D., F.R.S. L. & E., Professor of Physiology in the University of Glasgow. The University, Glasgow.
1883. ‡McKendrick, Mrs. The University, Glasgow.
1880. *Mackenzie, Colin. Junior Athenæum Club, Piccadilly, London, W.
1884. ‡McKenzie, Stephen, M.D. 26 Finsbury-circus, London, E.C.
1884. ‡McKenzie, Thomas, B.A. School of Science, Toronto, Canada.
1883. ‡Mackeson, Henry. Hythe, Kent.
1865. ‡Mackeson, Henry B., F.G.S. Hythe, Kent.
1872. *Mackey, J. A. 1 Westbourne-terrace, Hyde Park, London, W.

Year of Election.

1867. ‡Mackie, Samuel Joseph. 17 Howley-place, London, W.
1884. ‡McKilligan, John B. 387 Main-street, Winnipeg, Canada.
1887. §Mackinder, H. J., M.A., F.R.G.S. Christ Church, Oxford.
1867. *Mackinlay, David. 6 Great Western-terrace, Hillhead, Glasgow.
1889. §McKinley, Rev. D. 33 Milton-street, West Hartlepool.
1865. ‡Mackintosh, Daniel, F.G.S. 32 Glover-street, Birkenhead.
1884. *Mackintosh, James B. Consolidated Gas Company, 21st-street, and Avenue A, New York City, U.S.A.
1850. ‡Macknight, Alexander. 20 Albany-street, Edinburgh.
1867. ‡Mackson, H. G. 25 Cliff-road, Woodhouse, Leeds.
1872. *McLachlan, Robert, F.R.S., F.L.S. West View, Clarendon-road, Lewisham, S.E.
1873. ‡McLandsborough, John, M.Inst.C.E., F.R.A.S., F.G.S. Manningham, Bradford, Yorkshire.
1885. *M'Laren, The Right Hon. Lord, F.R.S.E. 46 Moray-place, Edinburgh.
1860. ‡Maclaren, Archibald. Summertown, Oxfordshire.
1873. ‡MacLaren, Walter S. B. Newington House, Edinburgh.
1882. ‡Maclean, Inspector-General, C.B. 1 Rockstone-terrace, Southampton.
1884. ‡McLennan, Frank. 317 Drummond-street, Montreal, Canada.
1884. ‡McLennan, Hugh. 317 Drummond-street, Montreal, Canada.
1884. ‡McLennan, John. Lancaster, Ontario, Canada.
1862. ‡Macleod, Henry Dunning. 17 Gloucester-terrace, Campden Hill-road, London, W.
1868. §M'Leod, Herbert, F.R.S., F.C.S., Professor of Chemistry in the Royal Indian Civil Engineering College, Cooper's Hill, Staines.
1875. ‡Macliver, D. 1 Broad-street, Bristol.
1875. ‡Macliver, P. S. 1 Broad-street, Bristol.
1861. *Maclure, John William, M.P., F.R.G.S., F.S.S. Whalley Range, Manchester.
1883. *McMahon, Major-General C. A. 20 Nevern-square, South Kensington, London, S.W.
1883. ‡MacMahon, Captain P. A., R.A., Instructor in Mathematics at the Royal Military Academy, Woolwich.
1878. *M'Master, George, M.A., J.P. Donnybrook, Ireland.
1862. ‡Macmillan, Alexander. Streatham-lane, Upper Tooting, Surrey, S.W.
1888. §McMillan, Robert. 20 Aubrey-street, Liverpool.
1874. ‡MacMordie, Hans, M.A. 8 Donegall-street, Belfast.
1884. ‡*McMurrick, Playfair. Ontario Agricultural College, Guelph, Ontario, Canada.*
1867. ‡M'Neill, John. Balhousie House, Perth.
1883. ‡McNicoll, Dr. E. D. 15 Manchester-road, Southport.
1878. ‡Macnie, George. 59 Bolton-street, Dublin.
1887. ‡Maconochie, Archibald White. Care of Messrs. Maconochie Bros., Lowestoft.
1883. ‡Macpherson, J. 44 Frederick-street, Edinburgh.
1886. ‡Macpherson, Lieut.-Colonel J. C., R.E. Ordnance Survey Office, Southampton.
1887. §McRae, Charles, M.A. Science and Art Department, South Kensington, London, S.W.
*Macrory, Edmund, M.A. 2 Ilchester-gardens, Prince's-square, London, W.
1883. ‡McWhirter, William. 170 Kent-road, Glasgow.
1887. ‡Macy, Jesse. Grinnell, Iowa, U.S.A.
1883. ‡Madden, W. H. Marlborough College, Wilts.
1883. ‡*Maggs, Thomas Charles, F.G.S. Culver Lodge, Acton Vale, Middlesex, W.*

Year of Election.

1868. ‡Magnay, F. A. Drayton, near Norwich.
1875. *Magnus, Sir Philip, B.Sc. 48 Gloucester-place, Portman-square, London, W.
1878. ‡Mahony, W. A. 34 College-green, Dublin.
1869. ‡Main, Robert. The Admiralty, Whitehall, London, S.W.
1887. ‡Mainprice, W. S. Longcroft, Altrincham, Cheshire.
1885. *Maitland, Sir James R. G., Bart. Stirling, N.B.
1883. §Maitland, P. C. 136 Great Portland-street, London, W.
*Malcolm, Frederick. Morden College, Blackheath, London, S.E.
1881. ‡Malcolm, Lieut.-Colonel, R.E. 72 Nunthorpe-road, York.
1874. ‡Malcolmson, A. B. Friends' Institute, Belfast.
1889. §Maling, C. T. 14 Ellison-place, Newcastle-upon-Tyne.
1857. ‡Mallet, John William, Ph.D., M.D., F.R.S., F.C.S., Professor of Chemistry in the University of Virginia, U.S.A.
1887. ‡MANCHESTER, The Right Rev. the Lord Bishop of, D.D. Bishop's Court, Manchester.
1870. ‡Manifold, W. H., M.D. 45 Rodney-street, Liverpool.
1885. ‡Mann, George. 72 Bon Accord-street, Aberdeen.
1888. ‡Mann, W. J. Rodney House, Trowbridge.
Manning, His Eminence Cardinal. Archbishop's House, Westminster, S.W.
1878. §Manning, Robert. 4 Upper Ely-place, Dublin.
1864. ‡Mansel-Pleydell, J. C. Whatcombe, Blandford.
1888. ‡Mansergh, James, M.Inst.C.E. 3 Westminster-chambers, London, S.W.
1889. §Manville, E. 3 Prince's-mansions, Victoria-street, London, S.W.
1887. *March, Henry Colley, M.D. 2 West-street, Rochdale.
1870. ‡Marcoartu, His Excellency Don Arturo de. Madrid.
1887. ‡Margetson, J. Charles. The Rocks, Limpley, Stoke.
1883. ‡Marginson, James Fleetwood. The Mount, Fleetwood, Lancashire.
1887. §Markham, Christopher A., F.R.Met.Soc. Sedgebrook, Northampton.
1864. ‡MARKHAM, CLEMENTS R., C.B., F.R.S., F.L.S., F.R.G.S., F.S.A. 21 Eccleston-square, London, S.W.
1863. ‡Marley, John. Mining Office, Darlington.
1888. §Marling, W. J. Stanley Park, Stroud, Gloucestershire.
1888. §Marling, Lady. Stanley Park, Stroud, Gloucestershire.
1881. *Marr, John Edward, M.A., F.G.S. St. John's College, Cambridge.
1888. §Marriott, A. S. Manor Lawn, Dewsbury.
1857. ‡Marriott, William, F.C.S. 8 Belgrave-terrace, Huddersfield.
1887. ‡Marsden, Benjamin. Westleigh, Heaton Mersey, Manchester.
1887. ‡Marsden, Joseph. Ardenlea, Heaton, near Bolton.
1884. *Marsden, Samuel. St. Louis, Missouri, U.S.A.
1883. *Marsh, Henry. Cressy House, Woodsley-road, Leeds.
1887. §Marsh, J. E., B.A. The Museum, Oxford.
1870. ‡Marsh, John. Rann Lea, Rainhill, Liverpool.
1864. ‡Marsh, Thomas Edward Miller. 37 Grosvenor-place, Bath.
1889. *MARSHALL, ALFRED, M.A., Professor of Political Economy in the University of Cambridge. Balliol Croft, Madingley-road, Cambridge.
1882. *MARSHALL, A. MILNES, M.A., M.D., D.Sc., F.R.S., Professor of Zoology in Owens College, Manchester.
1889. §Marshall, Frank, B.A. 31 Grosvenor-place, Newcastle-upon-Tyne.
1881. *Marshall, John, F.R.A.S., F.G.S. Church Institute, Leeds.
1881. ‡Marshall, John Ingham Fearby. 28 St. Saviourgate, York.
1876. ‡Marshall, Peter. 6 Parkgrove-terrace, Glasgow.
1858. ‡Marshall, Reginald Dykes. Adel, near Leeds.

Year of Election.

1889. *Marshall, Miss Sophie Elise, B.Sc. 38 Percy-gardens, Tynemouth.
1887. §Marshall, William. Thorncliffe, Dukinfield.
1886. *Marshall, William Bayley. 15 Augustus-road, Edgbaston, Birmingham.
1849. *MARSHALL, WILLIAM P., M.Inst.C.E. 15 Augustus-road, Birmingham.
1865. §MARTEN, EDWARD BINDON. Pedmore, near Stourbridge.
1883. ‡Marten, Henry John. 4 Storey's-gate, London, S.W.
1887. *Martin, Rev. H. A. Laxton Vicarage, Newark.
1848. ‡Martin, Henry D. 4 Imperial-circus, Cheltenham.
1878. ‡MARTIN, H. NEWELL, M.A., M.D., D.Sc., F.R.S., Professor of Biology in Johns Hopkins University, Baltimore, U.S.A.
1883. *MARTIN, JOHN BIDDULPH, M.A., F.S.S. 17 Hyde Park-gate, London, S.W.
1884. ‡Martin, N. H., F.L.S. 85 Osborne-road, Jesmond, Newcastle-upon-Tyne.
1889. *Martin, Thomas Henry, Assoc.M.Inst.C.E. Lyon House, New Barnet, Herts.
*Martineau, Rev. James, LL.D., D.D. 35 Gordon-square, London, W.C.
1865. ‡Martineau, R. F. 18 Highfield-road, Edgbaston, Birmingham.
1865. ‡Martineau, Thomas. 7 Cannon-street, Birmingham.
1886. ‡MARTINEAU, Sir THOMAS, J.P. West Hill, Augustus-road, Edgbaston, Birmingham.
1875. ‡*Martyn, Samuel, M.D. 8 Buckingham-villas, Clifton, Bristol.*
1883. ‡Marwick, James, LL.D. Killermont, Maryhill, Glasgow.
1878. ‡Masaki, Taiso. Japanese Consulate, 84 Bishopsgate-street Within, London, E.C.
1847. ‡MASKELYNE, NEVIL STORY, M.A., M.P., F.R.S., F.G.S., Professor of Mineralogy in the University of Oxford. Salthrop, Wroughton, Wiltshire.
1886. ‡Mason, Hon. J. E. Fiji.
1879. ‡Mason, James, M.D. Montgomery House, Sheffield.
1876. ‡Mason, Robert. 6 Albion-crescent, Dowanhill, Glasgow.
1876. ‡Mason, Stephen, M.P. 9 Rosslyn-terrace, Hillhead, Glasgow.
Massey, Lord Hugh. Hermitage, Castleconnel, Co. Limerick.
1885. ‡Masson, Orme, D.Sc. 58 Great King-street, Edinburgh.
1883. ‡Mather, Robert V. Birkdale Lodge, Birkdale, Southport.
1887. *Mather, William, M.P., M.Inst.C.E. Salford Iron Works, Manchester.
1865. *Mathews, G. S. 32 Augustus-road, Edgbaston, Birmingham.
1889. §Mathews, John Hitchcock. 1 Queen's-gardens, Hyde Park, London, W.
1861. *MATHEWS, WILLIAM, M.A., F.G.S. 60 Harborne-road, Birmingham.
1881. ‡Mathwin, Henry, B.A. Bickerton House, Southport.
1883. ‡Mathwin, Mrs. 40 York-road, Birkdale, Southport.
1865. ‡Matthews, C. E. Waterloo-street, Birmingham.
1858. ‡Matthews, F. C. Mandre Works, Driffield, Yorkshire.
1885. ‡MATTHEWS, JAMES. Springhill, Aberdeen.
1885. ‡Matthews, J. Duncan. Springhill, Aberdeen.
1863. ‡Maughan, Rev. W. Benwell Parsonage, Newcastle-on-Tyne.
1865. *MAW, GEORGE, F.L.S., F.G.S., F.S.A. Kenley, Surrey.
1876. ‡Maxton, John. 6 Belgrave-terrace, Glasgow.
1864. *Maxwell, Francis. 4 Moray-place, Edinburgh.
1887. ‡Maxwell, James. 29 Princess-street, Manchester.
*Maxwell, Robert Perceval. Finnebrogue, Downpatrick.
1883. §May, William, F.G.S., F.R.G.S. Northfield, St. Mary Cray, Kent.

Year of Election.

1883. †Mayall, George. Clairville, Birkdale, Southport.
1868. ‡*Mayall, J. E., F.C.S. Stork's Nest, Lancing, Sussex.*
1884. *Maybury, A. C., D.Sc. 19 Bloomsbury-square, London, W.C.
1835. Mayne, Edward Ellis. Rocklands, Stillorgan, Ireland.
1878. *Mayne, Thomas, M.P. 33 Castle-street, Dublin.
1863. ‡*Mease, George D. Lydney, Gloucestershire.*
1878. §Meath, The Right Rev. C. P. Reichel, D.D., Bishop of. Dundrum Castle, Dublin.
1884. ‡Mecham, Arthur. 11 Newton-terrace, Glasgow.
1881. ‡Meek, Sir James. Middlethorpe, York.
1871. †Meikie, James, F.S.S. 6 St. Andrew's-square, Edinburgh.
1879. §Meiklejohn, John W. S., M.D. 105 Holland-road, London, W.
1887. §Meischke-Smith, W. 31 Plantage, Amsterdam.
1881. *MELDOLA, RAPHAEL, F.R.S., F.R.A.S., F.C.S., F.I.C., Professor of Chemistry in the Finsbury Technical College, City and Guilds of London Institute. 6 Brunswick-square, London, W.C.
1867. †MELDRUM, CHARLES, C.M.G., M.A., F.R.S., F.R.A.S. Port Louis, Mauritius.
1883. †Mellis, Rev. James. 23 Park-street, Southport.
1879. *Mellish, Henry. Hodsock Priory, Worksop.
1866. †MELLO, Rev. J. M., M.A., F.G.S. Mapperley Vicarage, Derby.
1883. §Mello, Mrs. J. M. Mapperley Vicarage, Derby.
1881. §Melrose, James. Clifton, York.
1887. †Melvill, J. Cosmo, M.A. Kersal Cottage, Prestwich, Manchester.
1847. †Melville, Professor Alexander Gordon, M.D. Queen's College, Galway.
1863. ‡Melvin, Alexander. 42 Buccleuch-place, Edinburgh.
1877. *Menabrea, General Count, LL.D. 14 Rue de l'Elysée, Paris.
1862. §MENNELL, HENRY T. St. Dunstan's-buildings, Great Tower-street, London, E.C.
1879. §MERIVALE, JOHN HERMAN, M.A., Professor of Mining in the College of Science, Newcastle-upon-Tyne.
1879. ‡*Merivale, Walter. Indian Midland Railway, Saugor.*
1877. †Merrifield, John, Ph.D., F.R.A.S. Gascoigne-place, Plymouth.
1880. ‡Merry, Alfred S. Bryn Heulog, Sketty, near Swansea.
1889. *Merz, John Theodore. The Quarries, Newcastle-upon-Tyne.
1863. ‡Messent, P. T. 4 Northumberland-terrace, Tynemouth.
1869. †MIALL, LOUIS C., F.L.S., F.G.S., Professor of Biology in Yorkshire College, Leeds.
1886. ‡Middlemore, Thomas. Holloway Head, Birmingham.
1865. ‡Middlemore, William. Edgbaston, Birmingham.
1881. *Middlesbrough, The Right Rev. Richard Lacy, D.D., Bishop of, Middlesbrough.
1883. §Middleton, Henry. St. John's College, Cambridge.
1881. †Middleton, R. Morton, F.L.S., F.Z.S. South Pittsburg, Tennessee.
1886. *Middleton, Robert T. 197 West George-street, Glasgow.
1889. §Milburn, John D. Queen-street, Newcastle-upon-Tyne.
1886. ‡Miles, Charles Albert. Buenos Ayres.
1881. §MILES, MORRIS. Warbourne, Hill-lane, Southampton.
1885. §Mill, Hugh Robert, D.Sc., F.R.S.E. Braid-road, Morningside, Edinburgh.
1859. ‡Millar, John, J.P. Lisburn, Ireland.
1863. †Millar, John, M.D., F.L.S., F.G.S. Bethnal House, Cambridge-road, London, E.
1889. §Millar, Robert Cockburn. 56 George-street, Edinburgh.
Millar, Thomas, M.A., LL.D., F.R.S.E. Perth.
1876. †Millar, William. Highfield House, Dennistoun, Glasgow.

Year of
Election.

1876. ‡Millar, W. J. 145 Hill-street, Garnethill, Glasgow.
1882. ‡Miller, A. J. 12 Cumberland-place, Southampton.
1876. ‡Miller, Daniel. 258 St. George's-road, Glasgow.
1875. ‡Miller, George. Brentry, near Bristol.
1884. ‡Miller, Mrs. Hugh. 51 Lauriston-place, Edinburgh.
1888. §Miller, J. Bruce. Rubislaw Den North, Aberdeen.
1885. ‡Miller, John. 9 Rubislaw-terrace, Aberdeen.
1886. §Miller, Rev. John. The College, Weymouth.
1861. *Miller, Robert. Cranage Hall, Holmes Chapel, Cheshire.
1876. *Miller, Robert. 1 Lily Bank-terrace, Hillhead, Glasgow.
1884. ‡Miller, T. F., B.Ap.Sc. Napanee, Ontario, Canada.
1876. ‡Miller, Thomas Paterson. Cairns, Cambuslang, N.B.
1868. *Mills, Edmund J., D.Sc., F.R.S., F.C.S., Young Professor of Technical Chemistry in Anderson's College, Glasgow. 60 John-street, Glasgow.
1880. ‡Mills, Mansfeldt H. Tapton-grove, Chesterfield.
1885. ‡Milne, Alexander D. 40 Albyn-place, Aberdeen.
1882. *Milne, John, F.R.S., F.G.S., Professor of Geology in the Imperial College of Engineering, Tokio, Japan. Ingleside, Birdhirst Rise, South Croydon, Surrey.
1885. ‡Milne, J. D. 14 Rubislaw-terrace, Aberdeen.
1885. ‡Milne, William. 40 Albyn-place, Aberdeen.
1867. *Milne-Home, David, M.A., LL.D., F.R.S.E., F.G.S. 10 York-place, Edinburgh.
1887. §Milne-Redhead, R., F.L.S. Holden Clough, Clitheroe.
1882. ‡Milnes, Alfred, M.A., F.S.S. 30 Almeric-road, London, S.W.
1888. ‡Milsom, Charles. 69 Pulteney-street, Bath.
1880. ‡Minchin, G. M., M.A. Royal Indian Engineering College, Cooper's Hill, Surrey.
1855. ‡Mirrlees, James Buchanan. 45 Scotland-street, Glasgow.
1859. ‡Mitchell, Alexander, M.D. Old Rain, Aberdeen.
1876. ‡Mitchell, Andrew. 20 Woodside-place, Glasgow.
1883. ‡Mitchell, Charles T., M.A. 41 Addison-gardens North, Kensington, London, W.
1883. ‡Mitchell, Mrs. Charles T. 41 Addison-gardens North, Kensington, London, W.
1863. ‡Mitchell, C. Walker. Newcastle-on-Tyne.
1873. ‡Mitchell, Henry. Parkfield House, Bradford, Yorkshire.
1885. ‡Mitchell, Rev. J. Mitford, B.A. 6 Queen's-terrace, Aberdeen.
1870. §Mitchell, John, J.P. York House, Clitheroe, Lancashire.
1868. ‡Mitchell, John, jun. Pole Park House, Dundee.
1885. ‡Mitchell, P. Chalmers. Christ Church, Oxford.
1862. *Mitchell, W. Stephen, M.A., LL.B. Kenyon Mansions, Loughborough Park, London, S.W.
1879. ‡Mivart, St. George, M.D., F.R.S., F.L.S., F.Z.S., Professor of Biology in University College, Kensington. 16 Old Quebec-street, London, W.
1884. §Moat, Robert. Spring Grove, Bewdley.
1885. §Moffat, William. 7 Queen's-gardens, Aberdeen.
1864. ‡Mogg, John Rees. High Littleton House, near Bristol.
1885. ‡Moir, James. 25 Carden-place, Aberdeen.
1861. ‡Molesworth, Rev. Canon W. Nassau, M.A., LL.D. Spotland, Rochdale.
1883. ‡Mollison, W. L., M.A. Clare College, Cambridge.
1878. ‡Molloy, Constantine, Q.C. 65 Lower Leeson-street, Dublin.
1877. *Molloy, Rev. Gerald, D.D. 86 Stephen's-green, Dublin.
1884. ‡Monaghan, Patrick. Halifax (Box 317), Nova Scotia, Canada.

Year of Election.

1887. *Mond, Ludwig. 20 Avenue-road, Regent's Park, London, N.W.
1853. ‡Monroe, Henry, M.D. 10 North-street, Sculcoates, Hull.
1882. *Montagu, Samuel, M.P. 12 Kensington Palace-gardens, London, W.
1872. ‡Montgomery, R. Mortimer. 3 Porchester-place, Edgware-road, London, W.
1872. ‡Moon, W., LL.D. 104 Queen's-road, Brighton.
1884. ‡Moore, George Frederick. 25 Marlborough-road, Tue Brook, Liverpool.
1881. §Moore, Henry. Collingham, Maresfield-gardens, Fitzjohn's-avenue, London, N.W.
*Moore, John Carrick, M.A., F.R.S., F.G.S. 113 Eaton-square, London, S.W.; and Corswall, Wigtonshire.
1854. ‡Moore, Thomas John, Cor. M.Z.S. Free Public Museum, Liverpool.
1857. *Moore, Rev. William Prior. The Royal School, Cavan, Ireland.
1877. ‡Moore, William Vanderkemp. 15 Princess-square, Plymouth.
1871. ‡More, Alexander G., F.L.S., M.R.I.A. 74 Leinster-road, Dublin.
1881. ‡Morgan, Alfred. 50 West Bay-street, Jacksonville, Florida, U.S.A.
1873. ‡Morgan, Edward Delmar, F.R.G.S. 15 Roland-gardens, London, S.W.
1885. ‡Morgan, John. 57 Thomson-street, Aberdeen.
1887. ‡Morgan, John Gray. 38 Lloyd-street, Manchester.
1882. §Morgan, Thomas. Cross House, Southampton.
1878. ‡Morgan, William, Ph.D., F.C.S. Swansea.
1889. §Morison, J. Rutherford, M.D. 14 Saville-row, Newcastle-upon-Tyne.
1867. ‡Morison, William R. Dundee.
1883. *Morley, Henry Forster, M.A., D.Sc., F.C.S. 29 Kylemore-road, West Hampstead, London, N.W.
1889. §Morley, The Right Hon. John, LL.D., M.P. 95 Elm Park-gardens, London, S.W.
1881. ‡Morrell, W. W. York City and County Bank, York.
1880. ‡Morris, Alfred Arthur Vennor. Wernolau, Cross Inn R.S.O., Carmarthenshire.
1883. ‡Morris, C. S. Millbrook Iron Works, Landore, South Wales.
*Morris, Rev. Francis Orpen, B.A. Nunburnholme Rectory, Hayton, York.
1883. ‡Morris, George Lockwood. Millbrook Iron Works, Swansea.
1880. §Morris, James. 6 Windsor-street, Uplands, Swansea.
1883. ‡Morris, John. 40 Wellesley-road, Liverpool.
1888. ‡Morris, J. W., F.L.S. The Woodlands, Bathwick Hill, Bath.
1880. ‡Morris, M. I. E. The Lodge, Penclawdd, near Swansea.
Morris, Samuel, M.R.D.S. Fortview, Clontarf, near Dublin.
1876. ‡Morris, Rev. S. S. O., M.A., R.N., F.C.S. H.M.S. 'Garnet,' S. Coast of America.
1874. ‡Morrison, G. J., M.Inst.C.E. 5 Victoria-street, Westminster, S.W.
1871. *Morrison, James Darsie. 27 Grange-road, Edinburgh.
1886. ‡Morrison, John T. Scottish Marine Station, Granton, N.B.
1865. ‡Mortimer, J. R. St. John's-villas, Driffield.
1869. ‡Mortimer, William. Bedford-circus, Exeter.
1857. §Morton, George H., F.G.S. 209 Edge-lane, Liverpool.
1858. *Morton, Henry Joseph. 2 Westbourne-villas, Scarborough.
1871. ‡Morton, Hugh. Belvedere House, Trinity, Edinburgh.
1887. §Morton, Percy, M.A. Illtyd House, Brecon, South Wales.
1886. *Morton, P. F. 22 Granard-road, Wandsworth Common, Surrey, S.W.

Year of Election.

1868. ‡Moseley, H. N., M.A., LL.D., F.R.S., Linacre Professor of Human and Comparative Anatomy in the University of Oxford. Stretton Court, Parkstone, Dorset.
1883. ‡Moseley, Mrs. Stretton Court, Parkstone, Dorset.
Mosley, Sir Oswald, Bart., D.C.L. Rolleston Hall, Burton-upon-Trent, Staffordshire.
1878. *Moss, John Francis, F.R.G.S. Beechwood, Brincliffe, Sheffield.
1876. §Moss, Richard Jackson, F.C.S., M.R.I.A. St. Aubin's, Ballybrack, Co. Dublin.
1873. **Mosse, George Staley. 13 Scarsdale-villas, Kensington, London, W.*
1864. *Mosse, J. R. Conservative Club, London, S.W.
1873. ‡Mossman, William. Ovenden, Halifax.
1869. §Mott, Albert J., F.G.S. Detmore, Charlton Kings, Cheltenham.
1865. ‡*Mott, Charles Grey. The Park, Birkenhead.*
1866. §Mott, Frederick T., F.R.G.S. Birstall Hill, Leicester.
1862. *Mouat, Frederick John, M.D., Local Government Inspector. 12 Durham-villas, Campden Hill, London, W.
1856. ‡Mould, Rev. J. G., B.D. Fulmodeston Rectory, Dereham, Norfolk.
1878. *Moulton, J. Fletcher, M.A., Q.C., F.R.S. 57 Onslow-square, London, S.W.
1863. ‡Mounsey, Edward. Sunderland.
1861. *Mountcastle, William Robert. Bridge Farm, Ellenbrook, near Manchester.
1877. ‡Mount-Edgcumbe, The Right Hon. the Earl of, D.C.L. Mount-Edgcumbe, Devonport.
Mowbray, James. Combus, Clackmannan, Scotland.
1850. ‡Mowbray, John T. 15 Albany-street, Edinburgh.
1887. ‡Moxon, Thomas B. County Bank, Manchester.
1888. ‡Moyle, R. E., B.A., F.C.S. The College, Bath.
1886. *Moyles, Mrs. Thomas. The Beeches, Ladywood-road, Edgbaston, Birmingham.
1884. ‡Moyse, C. E., B.A., Professor of English Language and Literature in McGill College, Montreal. 802 Sherbrooke-street, Montreal, Canada.
1884. ‡Moyse, Charles E. 802 Sherbrooke-street, Montreal, Canada.
1876. *Muir, John. 6 Park-gardens, Glasgow.
1874. ‡Muir, M. M. Pattison, M.A., F.R.S.E. Caius College, Cambridge.
1876. ‡Muir, Thomas, M.A., LL.D., F.R.S.E. Beechcroft, Bothwell, Glasgow.
1884. *Muir, William Ker. Detroit, Michigan, U.S.A.
1872. ‡Muirhead, Alexander, D.Sc., F.C.S. Cowley-street, Westminster, S.W.
1871. *Muirhead, Henry, M.D., LL.D. Bushy Hill, Cambuslang, Lanarkshire.
1876. *Muirhead, Robert Franklin, M.A., B.Sc. Abbotsholme School, near Rocester, Stafford.
1884. *Muirhead-Paterson, Miss Mary. Laurieville, Queen's Drive, Crosshill, Glasgow.
1883. §Mulhall, Michael G. 19 Albion-street, Hyde Park, London, W.
1883. ‡Mulhall, Mrs. Marion. 19 Albion-street, Hyde Park, London, W.
1884. *Müller, Hugo, Ph.D., F.R.S., F.C.S. 13 Park-square East, Regent's Park, London, N.W.
1880. ‡Muller, Hugo M. 1 Grünanger-gasse, Vienna.
Munby, Arthur Joseph. 6 Fig-tree-court, Temple, London, E.C.
1866. ‡Mundella, The Right Hon. A. J., M.P., F.R.S., F.R.G.S. 16 Elvaston-place, London, S.W.
1876. ‡Munro, Donald, F.C.S. The University, Glasgow.
1885. ‡Munro, J. E. Crawford, LL.D., Professor of Political Economy in Owens College, Manchester.

Year of Election.

1883. *Munro, Robert. Braehead House, Kilmarnock, N.B.
1872. *Munster, H. Sillwood Lodge, Brighton.
1864. ‡MURCH, JEROM. Cranwells, Bath.
1864. *Murchison, K. R. Brockhurst, East Grinstead.
1855. ‡Murdoch, James B. Hamilton-place, Langside, Glasgow.
1889. §Murphy, James, M.A., M.D. Holly House, Sunderland.
1852. ‡Murphy, Joseph John. Old Forge, Dunmurry, Co. Antrim.
1884. §Murphy, Patrick. Newry, Ireland.
1887. ‡Murray, A. Hazeldean, Kersal, Manchester.
1869. ‡Murray, Adam. 78 Manor Road, Brockley, S.E.
Murray, John, F.G.S., F.R.G.S. 50 Albemarle-street, London, W.; and Newsted, Wimbledon, Surrey.
1859. ‡Murray, John, M.D. Forres, Scotland.
1884. ‡MURRAY, JOHN, F.R.S.E. 'Challenger' Expedition Office, Edinburgh.
1884. ‡Murray, J. Clark, LL.D., Professor of Logic and Mental and Moral Philosophy in McGill University, Montreal. 111 McKay-street, Montreal, Canada.
1872. ‡Murray, J. Jardine, F.R.C.S.E. 99 Montpellier-road, Brighton.
1863. ‡Murray, William, M.D. 34 Clayton-street, Newcastle-on-Tyne.
1883. ‡Murray, W. Vaughan. 4 Westbourne-crescent, Hyde Park, London, W.
1874. §Musgrave, James, J.P. Drumglass House, Belfast.
1870. *Muspratt, Edward Knowles. Seaforth Hall, near Liverpool.
1859. ‡MYLNE, ROBERT WILLIAM, F.R.S., F.G.S., F.S.A. 7 Whitehall-place, London, S.W.

1886. §Nagel, D. H., M.A. Trinity College, Oxford.
1876. ‡Napier, James S. 9 Woodside-place, Glasgow.
1876. *Napier, Captain Johnstone. Laverstock House, Salisbury.
1872. ‡Nares, Admiral Sir G. S., K.C.B., R.N., F.R.S., F.R.G.S. Maple-road, Surbiton.
1850. *NASMYTH, JAMES. Penshurst, Tunbridge.
1887. ‡Nason, Professor Henry B., Ph.D., F.C.S. Troy, New York, U.S.A.
1886. §Neale, E. Vansittart. 14 City-buildings, Corporation-street, Manchester.
1887. §Neild, Charles. 19 Chapel Walks, Manchester.
1883. *Neild, Theodore. Dalton Hall, Manchester.
1887. ‡Neill, Joseph S. Claremont, Broughton Park, Manchester.
1887. ‡Neill, Robert, jun. Beech Mount, Higher Broughton, Manchester.
1855. ‡Neilson, Walter. 172 West George-street, Glasgow.
1876. ‡Nelson, D. M. 11 Bothwell-street, Glasgow.
1888. ‡Nelson, The Right Rev. the Bishop of, D.D. Nelson, New Zealand.
1886. ‡Nettlefold, Edward. 51 Carpenter-road, Edgbaston, Birmingham.
1868. ‡Nevill, Rev. H. R. The Close, Norwich.
1866. *Nevill, The Right Rev. Samuel Tarratt, D.D., F.L.S., Bishop of Dunedin, New Zealand.
1889. §Neville, F. H. Sidney College, Cambridge.
1857. ‡*Neville, John, M.R.I.A. Roden-place, Dundalk, Ireland.*
1869. ‡Nevins, John Birkbeck, M.D. 3 Abercromby-square, Liverpool.
1842. New, Herbert. Evesham, Worcestershire.
1889. *Newall, H. Frank. Trumpington, Cambridge.
1886. §Newbolt, F. G. Edenhurst, Addlestone, Surrey.
1842. *NEWMAN, Professor FRANCIS WILLIAM. 15 Arundel-crescent, Weston-super-Mare.
1889. §Newstead, A. H. L. Roseacre, Epping.

Year of Election.

1860. *NEWTON, ALFRED, M.A., F.R.S., F.L.S., Professor of Zoology and Comparative Anatomy in the University of Cambridge. Magdalene College, Cambridge.
1883. ‡*Newton, A. W. 7a Westcliffe-road, Birkdale, Southport.*
1872. ‡Newton, Rev. J. 125 Eastern-road, Brighton.
1886. ‡Newton, William. 18 Fenchurch-street, London, E.C.
1883. ‡Nias, Miss Isabel. 56 Montagu-square, London, W.
1882. ‡Nias, J. B., B.A. 56 Montagu-square, London, W.
1867. ‡Nicholl, Thomas. Dundee.
1875. ‡Nicholls, J. F. City Library, Bristol.
1866. ‡NICHOLSON, Sir CHARLES, Bart., M.D., D.C.L., LL.D., F.G.S., F.R.G.S. The Grange, Totteridge, Herts.
1871. §Nicholson, E. Chambers. Herne Hill, London, S.E.
1867. ‡NICHOLSON, HENRY ALLEYNE, M.D., D.Sc., F.G.S., Professor of Natural History in the University of Aberdeen.
1887. *Nicholson, John Carr. Ashfield, Headingley, Leeds.
1884. §Nicholson, Joseph S., M.A., D.Sc., Professor of Political Economy in the University of Edinburgh. Eden Lodge, Newbattle-terrace, Edinburgh.
1883. ‡Nicholson, Richard, J.P. Whinfield, Hesketh Park, Southport.
1887. §Nicholson, Robert H. Bourchier. 21 Albion-street, Hull.
1881. ‡Nicholson, William R. Clifton, York.
1887. ‡Nickson, William. Shelton, Sibson-road, Sale, Manchester.
1885. §Nicol, W. W. J., M.A., D.Sc., F.R.S.E. Mason Science College, Birmingham.
1878. ‡Niven, Charles, M.A., F.R.S., F.R.A.S., Professor of Natural Philosophy in the University of Aberdeen. 6 Chanonry, Aberdeen.
1886. ‡Niven George. Erkingholme, Coolhurst-road, London, N.
1877. ‡Niven, James, M.A. King's College, Aberdeen.
1874. ‡Nixon, Randal C. J., M.A. Royal Academical Institution, Belfast.
1884. ‡Nixon, T. Alcock. 33 Harcourt-street, Dublin.
1863. *NOBLE, Captain ANDREW, C.B., F.R.S., F.R.A.S., F.C.S. Elswick Works, Newcastle-upon-Tyne.
1880. ‡*Noble, John. Rossenstein, Thornhill-road, Croydon, Surrey.*
1879. ‡Noble, T. S., F.G.S. Lendal, York.
1886. §Nock, J. B. Mayfield, Chester-road, Sutton Coldfield.
1887. ‡Nodal, John H. The Grange, Heaton Moor, near Stockport.
1870. ‡Nolan, Joseph, M.R.I.A. 14 Hume-street, Dublin.
1882. §Norfolk, F. Elm Villa, Ordnance-road, Southampton.
1859. ‡*Norfolk, Richard. Ladygate, Beverley.*
1863. ‡NORMAN, Rev. Canon ALFRED MERLE, M.A., D.C.L., F.L.S. Burnmoor Rectory, Fence Houses, Co. Durham.
1888. ‡Norman, George. 12 Brock-street, Bath.
Norreys, Sir Denham Jephson, Bart. Mallow Castle, Co. Cork.
1865. ‡NORRIS, RICHARD, M.D. 2 Walsall-road, Birchfield, Birmingham.
1872. ‡Norris, Thomas George. Gorphwysfa, Llanrwst, North Wales.
1883. *Norris, William G. Coalbrookdale, Shropshire.
1881. §North, Samuel William, M.R.C.S., F.G.S. 84 Micklegate, York.
1881. ‡*North, William, B.A., F.C.S. 28 Regent's Park-road, London, N.W.*
*NORTHWICK, The Right Hon. Lord, M.A. 7 Park-street, Grosvenor-square, London, W.
NORTON, The Right Hon. Lord, K.C.M.G. 35 Eaton-place, London, S.W.; and Hamshall, Birmingham.
1886. ‡Norton, Lady. 35 Eaton-place, London, S.W.; and Hamshall, Birmingham.

Year of Election.

1868. ‡Norwich, The Hon. and Right Rev. J. T. Pelham, D.D., Lord Bishop of Norwich.
1861. ‡Noton, Thomas. Priory House, Oldham.
Nowell, John. Farnley Wood, near Huddersfield.
1883. ‡Nunnerley, John. 46 Alexandra-road, Southport.
1887. §Nursey, Perry Fairfax. 161 Fleet-street, London, E.C.
1883. *Nutt, Miss Lilian. Rosendale Hall, West Dulwich, London, S.E.

1882. §Obach, Eugene, Ph.D. 2 Victoria-road, Old Charlton, Kent.
1878. ‡*O'Brien, Murrough. 1 Willow-terrace, Blackrock, Co. Dublin.*
O'Callaghan, George. Tallas, Co. Clare.
1888. ‡*O'Connell, Major-General P. 2 College-road, Lansdowne, Bath.*
1878. ‡O'Conor Don, The. Clonalis, Castlerea, Ireland.
1883. ‡Odgers, William Blake, M.A., LL.D. 4 Elm-court, Temple, London, E.C.
1858. *Odling, William, M.B., F.R.S., F.C.S., Waynflete Professor of Chemistry in the University of Oxford. 15 Norham-gardens, Oxford.
1884. ‡Odlum, Edward, M.A. Pembroke, Ontario, Canada.
1857. ‡O'Donnavan, William John. 54 Kenilworth-square, Rathgar, Dublin.
1877. ‡Ogden, Joseph. 13 Hythe-villas, Limes-road, Croydon.
1885. ‡Ogilvie, Alexander, LL.D. Gordon's College, Aberdeen.
1876. ‡Ogilvie, Campbell P. Sizewell House, Leiston, Suffolk.
1885. ‡Ogilvie, F. Grant, M.A., B.Sc. Gordon's College, Aberdeen.
1859. ‡Ogilvy, Rev. C. W. Norman. Baldovan House, Dundee.
1863. ‡Ogilvy, Sir John, Bart. Inverquharity, N.B.
*Ogle, William, M.D., M.A. The Elms, Derby.
1837. ‡O'Hagan, John, M.A., Q.C. 22 Upper Fitzwilliam-street, Dublin.
1884. §O'Halloran, J. S., F.R G.S. Royal Colonial Institute, Northumberland-avenue, London, W.C.
1881. ‡Oldfield, Joseph. Lendal, York.
1887. ‡Oldham, Charles. Syrian House, Sale, near Manchester.
1853. ‡Oldham, James, M.Inst.C.E. Cottingham, near Hull.
1885. ‡Oldham, John. River Plate Telegraph Company, Monte Video.
1863. ‡Oliver, Daniel, F.R.S., F.L.S., Emeritus Professor of Botany in University College, London. Royal Gardens, Kew, Surrey.
1887. §Oliver, F. W. Royal Gardens, Kew, Surrey.
1883. ‡Oliver, J. A. Westwood. The Liberal Club, Glasgow.
1883. §Oliver, Samuel A. Bellingham House, Wigan, Lancashire.
1889. §Oliver, Professor T., M.D. Eldon-square, Newcastle-upon-Tyne.
1882. §Olsen, O. T., F.R.A S., F.R.G.S. 116 St. Andrew's-terrace, Grimsby.
*Ommanney, Admiral Sir Erasmus, C.B., LL.D., F.R.S., F.R.A.S., F.R.G.S. 29 Connaught-square, Hyde Park, London, W.
1880. *Ommanney, Rev. E. A. 123 Vassal-road, Brixton, London, S.W.
1887. §O'Neill, Charles. 72 Denmark-road, Manchester.
1872. ‡Onslow, D. Robert. New University Club, St. James's, London, S.W.
1883. ‡Oppert, Gustav, Professor of Sanskrit. Madras.
1867. ‡Orchar, James G. 9 William-street, Forebank, Dundee.
1883. ‡Ord, Miss Maria. Fern Lea, Park-crescent, Southport.
1883. ‡Ord, Miss Sarah. Fern Lea, Park-crescent, Southport.
1880. ‡O'Reilly, J. P., Professor of Mining and Mineralogy in the Royal College of Science, Dublin.
1842. Ormerod, George Wareing, M.A., F.G.S. Woodway, Teignmouth.
1861. ‡Ormerod, Henry Mere. Clarence-street, Manchester; and 11 Woodland-terrace, Cheetham Hill, Manchester.

Year of Election.

1858. ‡Ormerod, T. T. Brighouse, near Halifax.
1883. ‡Orpen, Miss. 58 Stephen's-green, Dublin.
1884. *Orpen, Major R. T., R.E. Gibraltar.
1884. *Orpen, Rev. T. H., M.A. Binnbrooke, Cambridge.
1838. Orr, Alexander Smith. 57 Upper Sackville-street, Dublin.
1873. ‡Osborn, George. 47 Kingscross-street, Halifax.
1887. §O'Shea, L. J., B.Sc. Firth College, Sheffield.
*OSLER, A. FOLLETT, F.R.S. South Bank, Edgbaston, Birmingham.
1865. *Osler, Henry F. Coppy Hill, Linthurst, near Bromsgrove, Birmingham.
1869. *Osler, Sidney F. Chesham Lodge, Lower Norwood, Surrey, S.E.
1884. ‡Osler, William, M.D., Professor of the Institutes of Medicine in McGill University, Montreal, Canada.
1884. ‡O'Sullivan, James, F.C.S. 71 Spring Terrace-road, Burton-on-Trent.
1882. *Oswald, T. R. Castle Hall, Milford Haven.
1881. *Ottewell, Alfred D. 83 Siddals-road, Derby.
1882. ‡Owen, Rev. C. M., M.A. St. George's, Edgbaston, Birmingham.
OWEN, Sir RICHARD, K.C.B., M.D., D.C.L., LL.D., F.R.S., F.L.S., F.G.S., Hon. F.R.S.E. Sheen Lodge, Mortlake, Surrey, S.W.
1888. *Owen, Thomas. 8 Alfred-street, Bath.
1877. ‡Oxland, Dr. Robert, F.C.S. 8 Portland-square, Plymouth.

1889. §Page, Dr. F. 1 Saville-place, Newcastle-upon-Tyne.
1883. ‡Page, George W. Fakenham, Norfolk.
1883. ‡Page, Joseph Edward. 12 Saunders-street, Southport.
1872. *Paget, Joseph. Stuffynwood Hall, Mansfield, Nottingham.
1884. ‡Paine, Cyrus F. Rochester, New York, U.S.A.
1875. ‡Paine, William Henry, M.D., F.G.S. Stroud, Gloucestershire.
1870. *PALGRAVE, R. H. INGLIS, F.R.S., F.S.S. Belton, Great Yarmouth.
1883. ‡Palgrave, Mrs. R. H. Inglis. Belton, Great Yarmouth.
1889. §PALMER, Sir CHARLES MARK, Bart., M.P. Grinkle Park, Yorkshire.
1873. ‡Palmer, George, M.P. The Acacias, Reading, Berks.
1878. *Palmer, Joseph Edward. Lyons Mills, Straffan Station, Dublin.
1887. *Palmer, Miss Mary Kate. Kilburn House, Sherwood, Notts.
1866. §Palmer, William. Kilbourne House, Cavendish Hill, Sherwood, Notts.
1872. *Palmer, W. R. 1 The Cloisters, Temple, E.C.
Palmes, Rev. William Lindsay, M.A. Naburn Hall, York.
1883. §Pant, F. J. van der. Clifton Lodge, Kingston-on-Thames.
1886. ‡Panton, George A., F.R.S.E. 73 Westfield-road, Edgbaston, Birmingham.
1884. §Panton, Professor J. Hoyes, M.D. Ontario Agricultural College, Guelph, Ontario, Canada.
1883. ‡Park, Henry. Wigan.
1883. ‡Park, Mrs. Wigan.
1880. *Parke, George Henry, F.L.S., F.G.S. Barrow-in-Furness, Lancashire.
1863. ‡Parker, Henry. Low Elswick, Newcastle-upon-Tyne.
1863. ‡Parker, Rev. Henry. Idlerton Rectory, Low Elswick, Newcastle-upon-Tyne.
1874. ‡Parker, Henry R., LL.D. Methodist College, Belfast.
Parker, Richard. Dunscombe, Cork.
1886. ‡Parker, Lawley. Chad Lodge, Edgbaston, Birmingham.
1853. ‡Parker, William. Thornton-le-Moor, Lincolnshire.

Year of
Election.

1865. *Parkes, Samuel Hickling, F.L.S. 6 St. Mary's-row, Birmingham.
1864. †PARKES, WILLIAM. 23 Abingdon-street, Westminster, S.W.
1879. §Parkin, William, F.S.S. The Mount, Sheffield.
1887. §Parkinson, James. Station-road, Turton, Bolton.
1859. ‡Parkinson, Robert, Ph.D. West View, Toller-lane, Bradford, Yorkshire.
1841. Parnell, Edward A., F.C.S. Ashley Villa, Swansea.
1862. *Parnell, John, M.A. 1 The Common, Upper Clapton, London, E.
1883. †Parson, T. Cooke, M.R.C.S. Atherston House, Clifton, Bristol.
1877. ‡Parson, T. Edgcumbe. 36 Torrington-place, Plymouth.
1865. *Parsons, Charles Thomas. Norfolk-road, Edgbaston, Birmingham.
1878. †Parsons, Hon. C. A. Elvaston Hall, Newcastle-upon-Tyne.
1878. †*Parsons, Hon. and Rev. R. C. 10 Connaught-place, London, W.*
1883. ‡Part, Isabella. Rudleth, Watford, Herts.
1875. †Pass, Alfred C. Rushmere House, Durdham Down, Bristol.
1881. †Patchitt, Edward Cheshire. 128 Derby-road, Nottingham.
1884. *Paton, David. Johnstone, Scotland.
1883. *Paton, Henry, M.A. 15 Myrtle-terrace, Edinburgh.
1884. *Paton, Hugh. 992 Sherbrooke-street, Montreal, Canada.
1883. ‡Paton, Rev. William. The Ferns, Parkside, Nottingham.
1887. ‡Paterson, A. M., M.D. Owens College, Manchester.
1871. *Patterson, A. Henry. 3 New-square, Lincoln's Inn, London, W.C.
1884. †Patterson, Edward Mortimer. Fredericton, New Brunswick, Canada.
1867. ‡Patterson, James. Kinnettles, Dundee.
1876. §Patterson, T. L. Belmont, Margaret-street, Greenock.
1874. ‡Patterson, W. H., M.R.I.A. 26 High-street, Belfast.
1889. §Pattinson, H. L., jun. Felling Chemical Works, Felling-upon-Tyne.
1863. †PATTINSON, JOHN, F.C.S. 75 The Side, Newcastle-upon-Tyne.
1863. †Pattinson, William. Felling, near Newcastle-upon-Tyne.
1867. §Pattison, Samuel Rowles, F.G.S. 11 Queen Victoria-street, London, E.C.
1864. ‡Pattison, Dr. T. H. London-street, Edinburgh.
1879. *Patzer, F. R. Stoke-on-Trent.
1863. ‡PAUL, BENJAMIN H., Ph.D. 1 Victoria-street, Westminster, S.W.
1883. ‡*Paul, G., F.G.S. Filey, Yorkshire.*
1863. ‡PAVY, FREDERICK WILLIAM, M.D., F.R.S. 35 Grosvenor-street, London, W.
1887. ‡Paxman, James. Hill House, Colchester.
1887. *Payne, Miss Edith Annie. Hatchlands, Cuckfield, Hayward's Heath.
1881. †Payne, J. Buxton. 15 Mosley-street, Newcastle-upon-Tyne.
1877. *Payne, J. C. Charles. Botanic-avenue, The Plains, Belfast.
1881. ‡Payne, Mrs. Botanic-avenue, The Plains, Belfast.
1866. ‡Payne, Dr. Joseph F. 78 Wimpole-street, London, W.
1888. *Paynter, J. B. Hendford Manor House, Yeovil.
1886. †Payton, Henry. Eversleigh, Somerset-road, Birmingham.
1876. ‡Peace, G. H. Monton Grange, Eccles, near Manchester.
1879. ‡Peace, William K. Moor Lodge, Sheffield.
1885. †Peach, B. N., F.R.S.E., F.G.S. Geological Survey Office, Edinburgh.
1883. †Peacock, Ebenezer. 8 Mandeville-place, Manchester-square, London, W.
1875. †Peacock, Thomas Francis. 12 South-square, Gray's Inn, London, W.C.
1881. *PEARCE, HORACE, F.R.A.S., F.L.S., F.G.S. The Limes, Stourbridge.
1886. *Pearce, Mrs. Horace. The Limes, Stourbridge.

Year of Election.

1888. §Pearce, Rev. R. J., D.C.L., Professor of Mathematics in the University of Durham. St. Giles's Vicarage, Durham.
1882. §Pearce, Walter, M.B., B.Sc., F.C.S. St. Mary's Hospital, Paddington, London, W.; and Craufurd, Ray Mead, Maidenhead.
1884. ‡Pearce, William. Winnipeg, Canada.
1886. ‡Pearsall, Howard D. 3 Cursitor-street, London, E.C.
1887. ‡Pearse, J. Walter. Brussels.
1881. ‡Pearse, Richard Seward. Southampton.
1883. ‡Pearson, Arthur A. Colonial Office, London, S.W.
1883. ‡Pearson, Miss Helen E. 69 Alexandra-road, Southport.
1881. ‡Pearson, John. Glentworth House, The Mount, York.
1883. ‡Pearson, Mrs. Glentworth House, The Mount, York.
1872. *Pearson, Joseph. Grove Farm, Merlin, Raleigh, Ontario, Canada.
1881. ‡Pearson, Richard. 23 Bootham, York.
1870. ‡Pearson, Rev. Samuel, M.A. Highbury-quadrant, London, N.
1883. *Pearson, Thomas H. Redclyffe, Newton-le-Willows, Lancashire.
1863. §Pease, H. F. Brinkburn, Darlington.
1889. §Pease, Howard. Enfield Lodge, Benwell, Newcastle-upon-Tyne.
1863. ‡Pease, Sir Joseph W., Bart., M.P. Hutton Hall, near Guisborough.
1863. ‡Pease, J. W. Newcastle-upon-Tyne.
1883. ‡Peck, John Henry. 52 Hoghton-street, Southport.
Peckitt, Henry. Carlton Husthwaite, Thirsk, Yorkshire.
1855. *Peckover, Alexander, F.S.A., F.L.S., F.R.G.S. Bank House, Wisbech, Cambridgeshire.
1888. ‡Peckover, Miss Alexandrina. Bank House, Wisbech, Cambridgeshire.
*Peckover, Algernon, F.L.S. Sibald's Holme, Wisbech, Cambridgeshire.
1885. ‡Peddie, W. Spring Valley Villa, Morningside-road, Edinburgh.
1884. ‡Peebles, W. E. 9 North Frederick-street, Dublin.
1883. ‡Peek, C. E. Conservative Club, London, S.W.
1878. *Peek, William. 16 Belgrave-place, Brighton.
1881. ‡Peggs, J. Wallace. 21 Queen Anne's-gate, London, S.W.
1884. ‡Pegler, Alfred. Elmfield, Southampton.
1861. *Peile, George, jun. Shotley Bridge, Co. Durham.
1878. ‡Pemberton, Charles Seaton. 44 Lincoln's Inn-fields, London, W.C.
1865. ‡Pemberton, Oliver. 18 Temple-row, Birmingham.
1861. *Pender, Sir John, K.C.M.G. 18 Arlington-street, London, S.W.
1887. §Pendlebury, William H. 6 Gladstone-terrace, Priory Hill, Dover.
1856. §Pengelly, William, F.R.S., F.G.S. Lamorna, Torquay.
1881. ‡Penty, W. G. Melbourne-street, York.
1875. ‡Perceval, Rev. Canon John, M.A., LL.D. Rugby.
1889. §Percival, Archibald Stanley, M.A., M.B. 6 Lovaine-crescent, Newcastle-upon-Tyne.
*Perigal, Frederick. Cambridge Cottage, Kingswood, Reigate.
1886. ‡Perkin, T. Dix. Greenford Green, Harrow, Middlesex.
1868. *Perkin, William Henry, Ph.D., F.R.S., F.C.S. The Chestnuts, Sudbury, Harrow, Middlesex.
1884. ‡Perkin, William Henry, jun., Ph.D. Heriot Watt College, Edinburgh.
1877. ‡Perkins, Loftus. Seaford-street, Regent-square, London, W.C.
1864. *Perkins, V. R. Wotton-under-Edge, Gloucestershire.
1885. §Perrin, Miss Emily. 31 St John's Wood Park, London, N.W.
1886. ‡Perrin, Henry S. 31 St. John's Wood Park, London, N.W.
1886. ‡Perrin, Mrs. 23 Holland Villas-road, Kensington, London, W.
Perry, The Right Rev. Charles, M.A., D.D. 32 Avenue-road, Regent's Park, London, N.W.

Year of Election.

1879. ‡Perry, James. Roscommon.
1874. *PERRY, JOHN, M.E., D.Sc., F.R.S., Professor of Engineering and Applied Mathematics in the Technical College, Finsbury. 10 Penywern-road, South Kensington, London, S.W.
1883. ‡Perry, Ottley L., F.R.G.S. Bolton-le-Moors, Lancashire.
1883. ‡Perry, Russell R. 34 Duke-street, Brighton.
1886. ‡*Perry, William. Hanbury Villa, Stourbridge.*
1883. ‡Petrie, Miss Isabella. Stone Hill, Rochdale.
1871. *Peyton, John E. H., F.R.A.S., F.G.S. 5 Fourth-avenue, Brighton.
1882. ‡Pfoundes, Charles. Spring Gardens, London, S.W.
1886. ‡Phelps, Colonel A. 23 Augustus-road, Edgbaston, Birmingham.
1884. ‡Phelps, Charles Edgar. Carisbrooke House, The Park, Nottingham.
1884. ‡Phelps, Mrs. Carisbrooke House, The Park, Nottingham.
1886. ‡Phelps, Hon. E. J. American Legation, Members' Mansions, Victoria-street, London, S.W.
1886. ‡Phelps, Mrs. Hamshall, Birmingham.
1863. *PHENÉ, JOHN SAMUEL, LL.D., F.S.A., F.G.S., F.R.G.S. 5 Carlton-terrace, Oakley-street, London, S.W.
1870. ‡Philip, T. D. 51 South Castle-street, Liverpool.
1853. *Philips, Rev. Edward. Hollington, Uttoxeter, Staffordshire.
1853. *Philips, Herbert. The Oak House, Macclesfield.
Philips, Robert N., M.P. The Park, Manchester.
1877. §Philips, T. Wishart. Dunedin, Wanstead, Essex.
1863. ‡Philipson, Dr. 7 Eldon-square, Newcastle-upon-Tyne.
1889. §Philipson, John. 9 Victoria-square, Newcastle-upon-Tyne.
1883. ‡Phillips, Arthur G. 20 Canning-street, Liverpool.
1862. ‡Phillips, Rev. George, D.D. Queen's College, Cambridge.
1887. ‡Phillips, H. Harcourt, F.C.S. 18 Exchange-street, Manchester.
1880. §Phillips, John H., Hon. Sec. Philosophical and Archæological Society, Scarborough.
1883. ‡*Phillips, Mrs. Leah R. 1 East Park-terrace, Southampton.*
1883. ‡Phillips, S. Rees. Wonford House, Exeter.
1881. ‡Phillips, William. 9 Bootham-terrace, York.
1868. ‡PHIPSON, T. L., Ph.D., F.C.S. 4 The Cedars, Putney, Surrey, S.W.
1884. *Pickard, Rev. H. Adair, M.A. 5 Canterbury-road, Oxford.
1883. *Pickard, Joseph William. Lindow Cottage, Lancaster.
1885. *PICKERING, SPENCER U. 48 Bryanston-square, London, W.
1884. *Pickett, Thomas E., M.D. Maysville, Mason County, Kentucky, U.S.A.
1888. *Pidgeon, W. R. 42 Porchester-square, London, W.
1871. ‡Pigot, Thomas F., M.R.I.A. Royal College of Science, Dublin.
1884. ‡Pike, L. G., M.A., F.Z.S. 4 The Grove, Highgate, London, N.
1865. ‡PIKE, L. OWEN. 201 Maida-vale, London, W.
1873. ‡Pike, W. H. University College, Toronto, Canada.
1857. ‡Pilkington, Henry M., LL.D., Q.C. 45 Upper Mount-street, Dublin.
1883. ‡Pilling, R. C. The Robin's Nest, Blackburn.
Pim, George, M.R.I.A. Brenanstown, Cabinteely, Co. Dublin.
1877. ‡Pim, Joseph T. Greenbank, Monkstown, Co. Dublin.
1884. ‡*Pinart, A. G. N. L. 74 Market-street, San Francisco, U.S.A.*
1868. ‡Pinder, T. R. St. Andrew's, Norwich.
1876. ‡PIRIE, Rev. G., M.A., Professor of Mathematics in the University of Aberdeen. 33 College Bounds, Old Aberdeen.
1884. ‡Pirz, Anthony. Long Island, New York, U.S.A.
1887. ‡Pitkin, James. 56 Red Lion-street, Clerkenwell, London, E.C.
1875. ‡Pitman, John. Redcliff Hill, Bristol.

Year of Election.

1883. ‡Pitt, George Newton, M.A., M.D. 34 Ashburn-place, South Kensington, London, S.W.

1864. ‡Pitt, R. 5 Widcomb-terrace, Bath.

1883. §Pitt, Sydney. 34 Ashburn-place, South Kensington, London, S.W.

1868. ‡Pitt-Rivers, Lieut.-General A. H. L., D.C.L., F.R.S., F.G.S., F.S.A. 4 Grosvenor-gardens, London, S.W.

1872. ‡Plant, Mrs. H. W. 28 Evington-street, Leicester.

1869. ‡Plant, James, F.G.S. 40 West-terrace, West-street, Leicester.

1886. ‡*Player, J. H. 5 Prince of Wales-terrace, Kensington, London, W.*

1842. Playfair, The Right Hon. Sir Lyon, K.C.B., Ph.D., LL.D., M.P., F.R.S. L. & E., F.C.S. 68 Onslow-gardens, South Kensington, London, S.W.

1867. ‡Playfair, Lieut.-Colonel Sir R. L., K.C.M.G., H.M. Consul, Algeria. (Messrs. King & Co., Pall Mall, London, S.W.)

1884. *Playfair, W. S., M.D., LL.D., Professor of Midwifery in King's College, London. 31 George-street, Hanover-square, London, W.

1883. *Plimpton, R. T., M.D. 23 Lansdowne-road, Clapham-road, London, S.W.

1857. ‡Plunkett, Thomas. Ballybrophy House, Borris-in-Ossory, Ireland.

1861. *Pochin, Henry Davis, F.C.S. Bodnant Hall, near Conway.

1881. §Pocklington, Henry. 20 Park-row, Leeds.

1888. ‡Pocock, Rev. Francis. 4 Brunswick-place, Bath.

1846. ‡Pole, William, Mus.Doc., F.R.S., M.Inst.C.E. Athenæum Club, Pall Mall, London, S.W.

*Pollexfen, Rev. John Hutton, M.A. Middleton Tyas Vicarage, Richmond, Yorkshire.

Pollock, A. 52 Upper Sackville-street, Dublin.

1862. *Polwhele, Thomas Roxburgh, M.A., F.G.S. Polwhele, Truro, Cornwall.

1868. ‡Portal, Wyndham S. Malshanger, Basingstoke.

1883. *Porter, Rev. C. T., LL.D. Brechin Lodge, Cambridge-road, Southport.

1886. ‡Porter, Paxton. Birmingham and Midland Institute, Birmingham.

1866. ‡*Porter, Robert. Highfield, Long Eaton, Nottingham.*

1888. ‡Porter, Robert. Westfield House, Bloomfield-road, Bath.

1883. ‡Postgate, Professor J. P., M.A. Trinity College, Cambridge.

1863. ‡Potter, D. M. Cramlington, near Newcastle-on-Tyne.

1887. ‡Potter, Edmund P. Hollinhurst, Bolton.

1883. ‡Potter, M. C., M.A., F.L.S. St. Peter's College, Cambridge.

1883. §Potts, John. 33 Chester-road, Macclesfield.

1886. *Poulton, Edward B., M.A., F.R.S., F.L.S. Wykeham House, Oxford.

1873. *Powell, Francis S., M.P., F.R.G.S. Horton Old Hall, Yorkshire; and 1 Cambridge-square, London, W.

1887. *Powell, Horatio Gibbs. Wood Villa, Tettenhall Wood, Wolverhampton.

1883. ‡Powell, John. Wannarlwydd House, near Swansea.

1875. ‡Powell, William Augustus Frederick. Norland House, Clifton, Bristol.

1887. §Pownall, George H. Manchester and Salford Bank, Mosley-street, Manchester.

1867. ‡Powrie, James. Reswallie, Forfar.

1855. *Poynter, John E. Clyde Neuk, Uddingston, Scotland.

1883. ‡Poynting, J. H., M.A., F.R.S., Professor of Physics in the Mason College, Birmingham. 11 St. Augustine's-road, Birmingham.

1884. §Prance, Courtenay C. Hatherley Court, Cheltenham.

1884. *Prankerd, A. A., D.C.L. Brazenose College, Oxford.

Year of Election.

1869. *PREECE, WILLIAM HENRY, F.R.S., M.Inst.C.E. Gothic Lodge, Wimbledon Common, Surrey.
1888. *Preece, W. L. St. James's-terrace, London-road, Derby.
1884. *Premio-Real, His Excellency the Count of. Quebec, Canada.
1889. §Preston, Alfred Eley. 14 The Exchange, Bradford, Yorkshire.
*PRESTWICH, JOSEPH, M.A., D.C.L., F.R.S., F.G.S., F.C.S. Shoreham, near Sevenoaks.
1884. *Prevost, Major L. de T. 2nd Battalion Argyll and Sutherland Highlanders.
1871. ‡Price, Astley Paston. 47 Lincoln's-Inn-fields, London, W.C.
1856. *PRICE, Rev. BARTHOLOMEW, M.A., F.R.S., F.R.A.S., Sedleian Professor of Natural Philosophy in the University of Oxford. 11 St. Giles's, Oxford.
1872. ‡Price, David S., Ph.D. 26 Great George-street, Westminster, S.W.
1882. ‡Price, John E., F.S.A. 27 Bedford-place, Russell-square, London, W.C.
Price, J. T. Neath Abbey, Glamorganshire.
1888. §Price, L. L. F. R., M.A., F.S.S. Oriel College, Oxford.
1881. §Price, Peter. 12 Windsor-place, Cardiff.
1875. *Price, Rees. 163 Bath-street, Glasgow.
1875. *Price, William Philip. Tibberton Court, Gloucester.
1876. ‡Priestley, John. 174 Lloyd-street, Greenheys, Manchester.
1875. ‡Prince, Thomas. 6 Marlborough-road, Bradford, Yorkshire.
1883. ‡Prince, Thomas. Horsham-road, Dorking.
1864. *Prior, R. C. A., M.D. 48 York-terrace, Regent's Park, London, N.W.
1846. *PRITCHARD, Rev. CHARLES, D.D., F.R.S., F.G.S., F.R.A.S., Professor of Astronomy in the University of Oxford. 8 Keble-terrace, Oxford.
1889. *Pritchard, Eric Law. 12 Alwyne-place, Canonbury, London, N.
1876. *PRITCHARD, URBAN, M.D., F.R.C.S. 3 George-street, Hanover-square, London, W.
1888. ‡Probyn, Leslie C. Onslow-square, London, S.W.
1881. §Procter, John William. Ashcroft, Nunthorpe, York.
1863. ‡Proctor, R. S. Summerhill-terrace, Newcastle-on-Tyne.
Proctor, William. Elmhurst, Higher Erith-road, Torquay.
1885. ‡Profeit, Dr. Balmoral, N.B.
1863. ‡Proud, Joseph. South Hetton, Newcastle-upon-Tyne.
1884. *Proudfoot, Alexander. 2 Phillips-place, Montreal, Canada.
1879. *Prouse, Oswald Milton, F.G.S., F.R.G.S. 17 Disraeli-road, Putney, S.W.
1865. ‡Prowse, Albert P. Whitchurch Villa, Mannamead, Plymouth.
1872. *Pryor, M. Robert. Weston Manor, Stevenage, Herts.
1871. *Puckle, Thomas John. 42 Cadogan-place, London, S.W.
1873. ‡Pullan, Lawrence. Bridge of Allan, N.B.
1867. *Pullar, Robert, F.R.S.E. Tayside, Perth.
1883. *Pullar, Rufus D., F.C.S. Tayside, Perth.
1842. *Pumphrey, Charles. Southfield, King's Norton, near Birmingham.
1887. §PUMPHREY, WILLIAM. Lyncombe, Bath.
1885. §Purdie, Thomas, B.Sc., Ph.D., Professor of Chemistry in the University of St. Andrews. St. Andrews, N.B.
1852. ‡Purdon, Thomas Henry, M.D. Belfast.
1860. ‡PURDY, FREDERICK, F.S.S., Principal of the Statistical Department of the Poor Law Board, Whitehall, London. Victoria-road, Kensington, London, W.
1881. ‡Purey-Cust, Very Rev. Arthur Percival, M.A., Dean of York. The Deanery, York.
1882. ‡Purrott, Charles. West End, near Southampton.

Year of Election.

1874. ‡PURSER, FREDERICK, M.A. Rathmines, Dublin.
1866. ‡PURSER, Professor JOHN, M.A., M.R.I.A. Queen's College, Belfast.
1878. ‡Purser, John Mallet. 3 Wilton-terrace, Dublin.
1884. *Purves, W. Laidlaw. 20 Stafford-place, Oxford-street, London, W.
1860. *Pusey, S. E. B. Bouverie. Pusey House, Faringdon.
1883. §Pye-Smith, Arnold. 16 Fairfield-road, Croydon.
1883. §Pye-Smith, Mrs. 16 Fairfield-road, Croydon.
1868. ‡PYE-SMITH, P. H., M.D., F.R.S. 54 Harley-street, W.; and Guy's Hospital, London, S.E.
1879. §Pye-Smith, R. J. 350 Glossop-road, Sheffield.
1861. *Pyne, Joseph John. The Willows, Albert-road, Southport.

1888. ‡Quin, J. A., J.P. 14 South-parade, Bath.

1870. ‡Rabbits, W. T. Forest Hill, London, S.E.
1887. §Rabone, John. Penderell House, Hamstead-road, Birmingham.
1870. ‡Radcliffe, D. R. Phœnix Safe Works, Windsor, Liverpool.
1877. ‡Radford, George D. Mannamead, Plymouth.
1879. ‡Radford, R. Heber. Wood Bank, Pitsmoor, Sheffield.
*Radford, William, M.D. Sidmount, Sidmouth.
1855. *Radstock, The Right Hon. Lord. 70 Portland-place, London, W.
1888. ‡Radway, C. W. 9 Bath-street, Bath.
1878. ‡RAE, JOHN, M.D., LL.D., F.R.S., F.R.G.S. 4 Addison-gardens, Kensington, London, W.
1854. ‡Raffles, Thomas Stamford. 13 Abercromby-square, Liverpool.
1887. *Ragdale, John Rowland. Derby-place, Whitefield, Manchester.
1864. ‡Rainey, James T. St. George's Lodge, Bath.
Rake, Joseph. Charlotte-street, Bristol.
1885. ‡Ramsay, Major. Straloch, N.B.
1863. ‡RAMSAY, ALEXANDER, F.G.S. 2 Cowper-road, Acton, Middlesex, W.
1845. ‡RAMSAY, Sir ANDREW CROMBIE, LL.D., F.R.S., F.G.S. 7 Victoria-terrace, Beaumaris.
1884. ‡Ramsay, George G., LL.D., Professor of Humanity in the University of Glasgow. 6 The College, Glasgow.
1884. ‡Ramsay, Mrs. G. G. 6 The College, Glasgow.
1861. ‡Ramsay, John. Kildalton, Argyllshire.
1884. ‡RAMSAY, R. A. 1134 Sherbrooke-street, Montreal, Canada.
1889. §Ramsay, Major R. G. W. Bonnyrigg, Edinburgh.
1867. *Ramsay, W. F., M.D. Inveresk House, Nevern-road, London, S.W.
1876. *RAMSAY, WILLIAM, Ph.D., F.R.S., F.C.S., Professor of Chemistry in University College, London, W.C.
1883. ‡Ramsay, Mrs. 12 Arundel-gardens, London, W.
1887. ‡Ramsbottom, John. Fernhill, Alderley Edge, Cheshire.
1873. *Ramsden, William. Bracken Hall, Great Horton, Bradford Yorkshire.
1835. *Rance, Henry. St. Andrew's-street, Cambridge.
1869. *Rance, H. W. Henniker, LL.D. 10 Castletown-road, West Kensington, London, S.W.
1865. ‡Randel, J. 50 Vittoria-street, Birmingham.
1868. *Ransom, Edwin, F.R.G.S. Ashburnham-road, Bedford.
1863. §Ransom, William Henry, M.D., F.R.S. The Pavement, Nottingham.
1861. ‡Ransome, Arthur, M.A., M.D., F.R.S. Devisdale, Bowdon, Manchester.
Ransome, Thomas. Hest Bank, near Lancaster.
1872. *Ranyard, Arthur Cowper, F.R.A.S. 11 Stone-buildings, Lincoln's Inn, London, W.C.
1889. §Rapkin, J. B. Sidcup, Kent.
Rashleigh, Jonathan. 3 Cumberland-terrace, Regent's Park, London, N.W.

Year of Election.

1864. †Rate, Rev. John, M.A. Lapley Vicarage, Penkridge, Staffordshire.
1870. †Rathbone, Benson. Exchange-buildings, Liverpool.
1870. †Rathbone, Philip H. Greenbank Cottage, Wavertree, Liverpool.
1870. §Rathbone, R. R. Beechwood House, Liverpool.
1874. †RAVENSTEIN, E. G., F.R.G.S. 91 Upper Tulse-hill, London, S.W.
Rawdon, William Frederick, M.D. Bootham, York.
1889. §Rawlings, Edward. Richmond House, Wimbledon Common, Surrey.
1870. †Rawlins, G. W. The Hollies, Rainhill, Liverpool.
1866. *RAWLINSON, Rev. Canon GEORGE, M.A., Camden Professor of Ancient History in the University of Oxford. The Oaks, Precincts, Canterbury.
1855. *RAWLINSON, Major-General Sir HENRY C., G.C.B., LL.D., F.R.S., F.R.G.S. 21 Charles-street, Berkeley-square, London, W.
1887. †Rawson, Harry. Earlswood, Ellesmere Park, Eccles, Manchester.
1875. §RAWSON, Sir RAWSON W., K.C.M.G., C.B., F.R.G.S. 68 Cornwall-gardens, Queen's-gate, London, S.W.
1886. †Rawson, W. Stepney, M.A., F.C.S. 68 Cornwall-gardens, Queen's-gate, London, S.W.
1883. †Ray, Miss Catherine. Mount Cottage, Flask-walk, Hampstead, London, N.W.
1868. *RAYLEIGH, The Right Hon. Lord, M.A., D.C.L., LL.D., Sec.R.S., F.R.A.S., F.R.G.S., Professor of Natural Philosophy in the Royal Institution, London. Terling Place, Witham, Essex.
1883. *Rayne, Charles A., M.D., M.R.C.S. Queen-street, Lancaster.
*Read, W. H. Rudston, M.A., F.L.S. 12 Blake-street, York.
1870. †READE, THOMAS MELLARD, F.G.S. Blundellsands, Liverpool.
1884. §Readman, J. B., D.Sc., F.R.S.E. 9 Moray-place, Edinburgh.
1852. *REDFERN, Professor PETER, M.D. 4 Lower-crescent, Belfast.
1863. †Redmayne, Giles. 20 New Bond-street, London, W.
1889. §Redmayne, J. M. Harewood, Gateshead.
1889. §Redmayne, Norman. 26 Grey-street, Newcastle-upon-Tyne.
1888. †Rednall, Miss Edith E. Ashfield House, Neston, near Chester.
Redwood, Isaac. Cae Wern, near Neath, South Wales.
1861. †REED, Sir EDWARD J., K.C.B., M.P., F.R.S. 75 Harrington-gardens, London, S.W.
1889. §Reed, Rev. George. Bellingham Vicarage, Bardon Mill.
1888. †Rees, W. L. 11 North-crescent, Bedford-square, London, W.C.
1875. †Rees-Mogg, W. Wooldridge. Cholwell House, near Bristol.
1881. §Reid, Arthur S., B.A., F.G.S. Trinity College, Glenalmond, N.B.
1883. *REID, CLEMENT, F.G.S. 28 Jermyn-street, London, S.W.
1889. §Reid, George, Belgian Consul. Leazes House, Newcastle-upon-Tyne.
1876. †Reid, James. 10 Woodside-terrace, Glasgow.
1884. †Reid, Rev. James, B.A. Bay City, Michigan, U.S.A.
1887. *Reid, Walter Francis. Fieldside, Addlestone, Surrey.
1850. †Reid, William, M.D. Cruivie, Cupar Fife.
1881. †Reid, William. 19½ Blake-street, York.
1875. §REINOLD, A. W., M.A., F.R.S., Professor of Physical Science in the Royal Naval College, Greenwich, S.E.
1863. §RENALS, E. 'Nottingham Express' Office, Nottingham.
1885. †Rennett, Dr. 12 Golden-square, Aberdeen.
1889. *Rennie, George B. Hooley Lodge, Redhill.
1867. †Renny, W. W. 8 Douglas-terrace, Broughty Ferry, Dundee.
1884. †*Retallack, Captain Francis. 6 Beauchamp-avenue, Leamington.*
1883. *Reynolds, A. H. Manchester and Salford Bank, Southport.

Year of Election.

1871. ‡REYNOLDS, JAMES EMERSON, M.D., F.R.S., F.C.S., M.R.I.A., Professor of Chemistry in the University of Dublin. The Laboratory, Trinity College, Dublin.

1870. *REYNOLDS, OSBORNE, M.A., LL.D., F.R.S., M.Inst.C.E., Professor of Engineering in Owens College, Manchester. 23 Lady Barn-road, Fallowfield, Manchester.

1858. §REYNOLDS, RICHARD, F.C.S. 13 Briggate, Leeds.

1887. §Rhodes, George W. The Cottage, Victoria Park, Manchester.

1883. ‡Rhodes, Dr. James. 25 Victoria-street, Glossop.

1858. *Rhodes, John. 18 Albion-street, Leeds.

1877. *Rhodes, John. 360 Blackburn-road, Accrington, Lancashire.

1888. §Rhodes, John George. Beckenham, Kent.

1884. ‡Rhodes, Lieut.-Colonel William. Quebec, Canada.

1877. *Riccardi, Dr. Paul, Secretary of the Society of Naturalists. Via Stimmate, 15, Modena, Italy.

1889. §Richards, Professor T. W., Ph.D. Cambridge, Massachusetts, U.S.A.

1888. *RICHARDSON, ARTHUR, M.D. University College, Bristol.

1863. ‡RICHARDSON, BENJAMIN WARD, M.A., M.D., LL.D., F.R.S. 25 Manchester-square, London, W.

1861. ‡Richardson, Charles. 10 Berkeley-square, Bristol.

1869. *Richardson, Charles. 4 Northumberland-avenue, Putney, S.W.

1863. *Richardson, Edward. Warkworth, Northumberland.

1887. *Richardson, Miss Emma. Conway House, Dunmurry, Co. Antrim.

1882. §Richardson, Rev. George, M.A. The College, Winchester.

1884. *Richardson, George Straker. Isthmian Club, 150 Piccadilly, London, W.

1889. §Richardson, Hugh. Sedbergh School, Sedbergh R.S.O., Yorkshire.

1884. *Richardson, J. Clarke. Derwen Fawr, Swansea.

1870. ‡Richardson, Ralph, F.R.S.E. 10 Magdala-place, Edinburgh.

1889. §Richardson, Thomas, J.P. 7 Windsor-terrace, Newcastle-upon-Tyne.

1881. ‡Richardson, W. B. Elm Bank, York.

1861. ‡Richardson, William. 4 Edward-street, Werneth, Oldham.

1876. §Richardson, William Haden. City Glass Works, Glasgow.

1886. §Richmond, Robert. Leighton Buzzard.

1863. ‡Richter, Otto, Ph.D. 407 St. Vincent-street, Glasgow.

1868. ‡RICKETTS, CHARLES, M.D., F.G.S. 18 Hamilton-square, Birkenhead.

1877. ‡Ricketts, James, M.D. St. Helens, Lancashire.

*RIDDELL, Major-General CHARLES J. BUCHANAN, C.B., R.A., F.R.S. Oaklands, Chudleigh, Devon.

1883. *Rideal, Samuel. 161 Devonshire-road, Forest Hill, Kent, S.E.

1872. ‡*Ridge, James. 98 Queen's-road, Brighton.*

1862. ‡Ridgway, Henry Ackroyd, B.A. Bank Field, Halifax.

1861. ‡Ridley, John. 19 Belsize-park, Hampstead, London, N.W.

1889. §Ridley, Thomas D. Coatham, Redcar.

1884. ‡Ridout, Thomas. Ottawa, Canada.

1863. *Rigby, Samuel. Fern Bank, Liverpool-road, Chester.

1881. *Rigg, Arthur. 71 Warrington-crescent, London, W.

1883. *RIGG, EDWARD, M.A. Royal Mint, London, E.

1883. ‡Rigg, F. F., M.A. 32 Queen's-road, Southport.

1883. *Rigge, Samuel Taylor, F.S.A. Balmoral-place, Halifax.

1873. ‡Ripley, Sir Edward, Bart. Acacia, Apperley, near Leeds.

*RIPON, The Most Hon. the Marquis of, K.G., G.C.S.I., C.I.E., D.C.L., F.R.S., F.L.S., F.R.G.S. 9 Chelsea Embankment, London, S.W.

Year of Election.

1867. ‡Ritchie, John. Fleuchar Craig, Dundee.
1855. ‡*Ritchie, Robert. 14 Hill-street, Edinburgh.*
1867. ‡Ritchie, William. Emslea, Dundee.
1889. §Ritson, U. A. 1 Jesmond-gardens, Newcastle-upon-Tyne.
1869. *Rivington, John. Babbicombe, near Torquay.
1888. §Robb, W. J. Firth College, Sheffield.
1854. ‡Robberds, Rev. John, B.A. Battledown Tower, Cheltenham.
1869. *ROBBINS, JOHN, F.C.S. 57 Warrington-crescent, Maida Vale, London, W.
1878. ‡Roberts, Charles, F.R.C.S. 2 Bolton-row, London, W.
1887. *Roberts, Evan. 3 Laurel-bank, Alexandra-road, Manchester.
1859. ‡Roberts, George Christopher. Hull.
1870. *ROBERTS, ISAAC, F.G.S. Kennessee, Maghull, Lancashire.
1883. ‡*Roberts, Ralph A. 23 Clyde-road, Dublin.*
1881. ‡Roberts, R. D., M.A., D.Sc., F.G.S. Clare College, Cambridge.
1879. ‡Roberts, Samuel. The Towers, Sheffield.
1879. ‡Roberts, Samuel, jun. The Towers, Sheffield.
1883. ‡ROBERTS, Sir WILLIAM, M.D., F.R.S. 8 Manchester-square, London, W.
1868. *ROBERTS-AUSTEN, W. CHANDLER, F.R.S., F.C.S., Chemist to the Royal Mint, and Professor of Metallurgy in the Royal School of Mines. Royal Mint, London, E.
1883. ‡Robertson, Alexander. Montreal, Canada.
1884. *Robertson, Andrew. Elmbank, Dorchester-street, Montreal, Canada.
1859. ‡Robertson, Dr. Andrew. Indego, Aberdeen.
1884. ‡Robertson, E. Stanley, M.A. 43 Waterloo-road, Dublin.
1871. ‡Robertson, George, M.Inst.C.E., F.R.S.E. 47 Albany-street, Edinburgh.
1883. ‡Robertson, George H. The Nook, Gateacre, near Liverpool.
1883. ‡Robertson, Mrs. George H. The Nook, Gateacre, near Liverpool.
1876. ‡Robertson, R. A. Newthorn, Ayton-road, Pollokshields, Glasgow.
1888. *Robins, Edward Cookworthy, F.S.A. 46 Berners-street, Oxford-street, London, W.
1886. *Robinson, C. R. 27 Elvetham-road, Birmingham.
1886. §Robinson, Edward E. 56 Dovey-street, Liverpool.
1861. ‡Robinson, Enoch. Dukinfield, Ashton-under-Lyne.
1852. ‡Robinson, Rev. George. Beech Hill, Armagh.
1887. ‡Robinson, Henry. 7 Westminster-chambers, London, S.W.
1873. ‡Robinson, Hugh. 82 Donegall-street, Belfast.
1887. ‡Robinson, James. Akroydon Villa, Halifax, Yorkshire.
1861. ‡ROBINSON, JOHN, M.Inst.C.E. Atlas Works, Manchester.
1888. §Robinson, John. Engineer's Office, Barry, Cardiff.
1863. ‡Robinson, J. H. 6 Montallo-terrace, Barnard Castle.
1878. ‡Robinson, John L. 198 Great Brunswick-street, Dublin.
1876. ‡Robinson, M. E. 6 Park-circus, Glasgow.
1887. §Robinson, Richard. Bellfield Mill, Rochdale.
1881. ‡Robinson, Richard Atkinson. 195 Brompton-road, London, S.W.
1875. *Robinson, Robert, M.Inst.C.E., F.G.S. Beechwood, Darlington.
1884. ‡Robinson, Stillman. Columbus, Ohio, U.S.A.
1863. ‡Robinson, T. W. U. Houghton-le-Spring, Durham.
1888. §Robottom, Arthur. 3 St. Alban's-villas, Highgate-road, London, N.W.
1870. *Robson, E. R. Palace Chambers, 9 Bridge-street, Westminster, S.W.
1876. ‡Robson, Hazleton R. 14 Royal-crescent West, Glasgow.
1855. ‡*Robson, Neil. 127 St. Vincent-street, Glasgow.*
1872. *Robson, William. Marchholm, Gillsland-road, Merchiston, Edinburgh.

Year of Election.

1885. §Rodger, Edward. 1 Claremont-gardens, Glasgow.
1885. *Rodriguez, Epifanio. 12 John-street, Adelphi, London, W.C.
1872. ‡Rodwell, George F., F.R.A.S., F.C.S. Marlborough College, Wiltshire.
1866. ‡Roe, Thomas. Grove-villas, Sitchurch.
1860. ‡Rogers, James E. Thorold, Professor of Political Economy in the University of Oxford. Beaumont-street, Oxford.
1867. ‡Rogers, James S. Rosemill, by Dundee.
1883. ‡Rogers, Major R. Alma House, Cheltenham.
1882. §Rogers, Rev. Saltren, M.A. Gwennap, Redruth, Cornwall.
1883. ‡Rogers, Thomas Stanley, LL.B. 77 Albert-road, Southport.
1884. *Rogers, Walter M. Lamowa, Falmouth.
1886. ‡Rogers, W. Woodbourne. Wheeley's-road, Edgbaston, Birmingham.
1889. §Rogerson, John. Croxdale Hall, Durham.
1876. §Rollit, Sir A. K., M.P., B.A., LL.D., D.C.L., F.R.A.S., Hon. Fellow K.C.L. Thwaite House, Cottingham, East Yorkshire.
1876. ‡Romanes, George John, M.A., LL.D., F.R.S., F.L.S. 18 Cornwall-terrace, Regent's Park, London, N.W.
1846. ‡Ronalds, Edmund, Ph.D. Stewartfield, Bonnington, Edinburgh.
1869. ‡Roper, C. H. Magdalen-street, Exeter.
1872. *Roper, Freeman Clarke Samuel, F.L.S., F.G.S. Palgrave House, Eastbourne.
1881. *Roper, W. O. Eadenbreck, Lancaster.
1855. *Roscoe, Sir Henry Enfield, B.A., Ph.D., LL.D., D.C.L., M.P., F.R.S., F.C.S. 10 Bramham-gardens, London, S.W.
1883. *Rose, J. Holland, M.A. Aboyne, Bedford Hill-road, Balham, London, S.W.
1885. ‡Ross, Alexander. Riverfield, Inverness.
1874. ‡Ross, Alexander Milton, M.A., M.D., F.G.S. Toronto, Canada.
1857. ‡Ross, David, LL.D. 32 Nelson-street, Dublin.
1887. ‡Ross, Edward. Marple, Cheshire.
1880. ‡Ross, Captain G. E. A., F.R.G.S. 8 Collingham-gardens, Cromwell-road, London, S.W.
1872. ‡Ross, James, M.D. Tenterfield House, Waterfoot, near Manchester.
1859. *Ross, Rev. James Coulman. Baldon Vicarage, Oxford.
1874. ‡*Ross, Rev. William. Chapelhill Manse, Rothesay, Scotland.*
1880. ‡*Ross, Major William Alexander. Acton House, Acton, London, W.*
1869. *Rosse, The Right Hon. the Earl of, B.A., D.C.L., LL.D., F.R.S., F.R.A.S., M.R.I.A. Birr Castle, Parsonstown, Ireland.
1865. *Rothera, George Bell. 17 Waverley-street, Nottingham.
1876. ‡Rottenburgh, Paul. 13 Albion-crescent, Glasgow.
1884. *Rouse, M. L. 343 Church-street, Toronto, Canada.
1861. ‡Routh, Edward J., M.A., D.Sc., F.R.S., F.R.A.S., F.G.S. St. Peter's College, Cambridge.
1881. ‡*Routh, Rev. William, M.A. Clifton Green, York.*
1861. ‡Rowan, David. Elliot-street, Glasgow.
1883. ‡Rowan, Frederick John. 134 St. Vincent-street, Glasgow.
1887. ‡Rowe, Rev. Alfred W., M.A., F.G.S. Felstead, Essex.
1881. ‡Rowe, Rev. G. Lord Mayor's Walk, York.
1865. ‡Rowe, Rev. John. 13 Hampton-road, Forest Gate, Essex.
1877. ‡Rowe, J. Brooking, F.L.S., F.S.A. 16 Lockyer-street, Plymouth.
1855. *Rowney, Thomas H., Ph.D., F.C.S., Professor of Chemistry in Queen's College, Galway. Salerno, Salthill, Galway.
1881. *Rowntree, Joseph. 37 St. Mary's, York.
1881. *Rowntree, J. S. The Mount, York.

Year of Election.

1862. ‡Rowsell, Rev. Evan Edward, M.A. Hambledon Rectory, Godalming.
1876. ‡Roxburgh, John. 7 Royal Bank-terrace, Glasgow.
1883. ‡Roy, Charles S., M.D., F.R.S., Professor of Pathology in the University of Cambridge. Trinity College, Cambridge.
1885. ‡Roy, John. 33 Belvidere-street, Aberdeen.
1888. ‡Roy, Parbati Churn, B.A. Calcutta, Bengal, India.
1861. *Royle, Peter, M.D., L.R.C.P., M.R.C.S. 27 Lever-street, Manchester.
1875. ‡RÜCKER, A. W., M.A., F.R.S., Professor of Physics in the Royal School of Mines. Errington, Clapham Park, London, S.W.
1869. §RUDLER, F. W., F.G.S. The Museum, Jermyn-street, London, S.W.
1882. ‡Rumball, Thomas, M.Inst.C.E. 8 Queen Anne's-gate, London, S.W.
1884. §Runtz, John. Linton Lodge, Lordship-road, Stoke Newington, London, N.
1887. §Ruscoe, John, F.G.S. Ferndale, Gee Cross, near Manchester.
1847. ‡RUSKIN, JOHN, M.A., F.G.S. Brantwood, Coniston, Ambleside.
1889. §Russell, The Right Hon. Earl. Teddington, Middlesex.
1875. *Russell, The Hon. F. A. R. Pembroke Lodge, Richmond Park, Surrey.
1884. ‡*Russell, George. Hoe Park House, Plymouth.*
1883. *Russell, J. W. Merton College, Oxford.
Russell, John. 39 Mountjoy-square, Dublin.
1852. *Russell, Norman Scott. Arts Club, Hanover-square, London, W.
1876. §Russell, R., F.G.S. 1 Sea View, St. Bees, Carnforth.
1886. ‡Russell, Thomas H. 3 Newhall-street, Birmingham.
1862. §RUSSELL, W. H. L., B.A., F.R.S. 50 South-grove, Highgate, London, N.
1852. *RUSSELL, WILLIAM J., Ph.D., F.R.S., F.C.S., Lecturer on Chemistry in St. Bartholomew's Medical College. 34 Upper Hamilton-terrace, St. John's Wood, London, N.W.
1886. §Rust, Arthur. Eversleigh, Leicester.
1883. *Ruston, Joseph, M.P. Monk's Manor, Lincoln.
1889. §Rutherford, Rev. Dr. 6 Eldon-square, Newcastle-upon-Tyne.
1871. §RUTHERFORD, WILLIAM, M.D., F.R.S., F.R.S.E., Professor of the Institutes of Medicine in the University of Edinburgh.
1887. §Rutherford, William. 7 Vine-grove, Chapman-street, Hulme, Manchester.
1881. ‡Rutson, Albert. Newby Wiske, Thirsk.
Rutson, William. Newby Wiske, Northallerton, Yorkshire.
1879. ‡Ruxton, Vice-Admiral Fitzherbert, R.N., F.R.G.S. 41 Cromwell-gardens, London, S.W.
1875. ‡Ryalls, Charles Wager, LL.D. 3 Brick-court, Temple, London, E.C.
1889. §Ryder, W. J. H. 52 Jesmond-road, Newcastle-upon-Tyne.
1886. ‡Ryland, F. Augustus-road, Edgbaston, Birmingham.
1865. ‡Ryland, Thomas. The Redlands, Erdington, Birmingham.
1861. *RYLANDS, THOMAS GLAZEBROOK, F.L.S., F.G.S. Highfields, Thelwall, near Warrington.

1883. **Sabine, Robert. 3 Great Winchester-street-buildings, London, E.C.*
1883. ‡Sadler, Robert. 7 Lulworth-road, Birkdale, Southport.
1871. ‡Sadler, Samuel Champernowne. Purton Court, Purton, near Swindon, Wiltshire.
1885. §Saint, W. Johnston. 11 Queen's-road, Aberdeen.
1866. *St. Albans, His Grace the Duke of. Bestwood Lodge, Arnold, near Nottingham.

Year of Election.

1886. §St. Clair, George, F.G.S. 127 Bristol-road, Birmingham.
1887. *Salford, the Right Rev. the Bishop of. Bishop's House, Salford.
1881. ‡Salkeld, William. 4 Paradise-terrace, Darlington.
1857. ‡Salmon, Rev. George, D.D., D.C.L., LL.D., F.R.S., Provost of Trinity College, Dublin.
1883. ‡Salmond, Robert G. The Nook, Kingswood-road, Upper Norwood. S.E.
1873. *Salomons, Sir David, Bart. Broomhill, Tunbridge Wells.
1883. ‡*Salt, Shirley H., M.A. 73 Queensborough-terrace, London, W.*
1872. ‡Salvin, Osbert, M.A., F.R.S., F.L.S. Hawksfold, Haslemere.
1887. §Samson, C. L. Carmona, Kersal, Manchester.
1861. *Samson, Henry. 6 St. Peter's-square, Manchester.
1861. *Sandeman, Archibald, M.A. Garry Cottage, Perth.
1883. ‡Sandeman, E. 53 Newton-street, Greenock.
1878. ‡Sanders, Alfred, F.L.S. 2 Clarence-place, Gravesend, Kent.
1883. *Sanders, Charles J. B. Pennsylvania, Exeter.
1884. ‡Sanders, Henry. 185 James-street, Montreal, Canada.
1872. ‡*Sanders, Mrs. 8 Powis-square, Brighton.*
1883. ‡Sanderson, Surgeon Alfred. East India United Service Club, St. James's-square, London, S.W.
1872. ‡Sanderson, J. S. Burdon, M.D., LL.D., D.C.L., F.R.S., Professor of Physiology in the University of Oxford. 64 Banbury-road, Oxford.
1883. ‡Sanderson, Mrs. Burdon. 64 Banbury-road, Oxford.
Sandes, Thomas, A.B. Sallow Glin, Tarbert, Co. Kerry.
1864. ‡Sandford, William. 9 Springfield-place, Bath.
1886. §Sankey, Percy E. Lyndhurst, St. Peter's, Kent.
1886. ‡Sauborn, John Wentworth. Albion, New York, U.S.A.
1886. ‡Saundby, Robert, M.D. 83A Edmund-street, Birmingham.
1868. ‡Saunders, A., M.Inst.C.E. King's Lynn.
1886. ‡Saunders, C. T. Temple-row, Birmingham.
1881. ‡Saunders, Howard, F.L.S., F.Z.S. 7 Radnor-place, London, W.
1883. ‡Saunders, Rev. J. C. Cambridge.
1846. ‡Saunders, Trelawney W., F.R.G.S. 3 Elmfield on the Knowles, Newton Abbot, Devon.
1884. ‡Saunders, William. London, Ontario, Canada.
1884. ‡Saunderson, C. E. 26 St. Famille-street, Montreal, Canada.
1887. §Savage, Rev. E. B., M.A. St. Thomas' Parsonage, Douglas, Isle of Man.
1871. §Savage, W. D. Ellerslie House, Brighton.
1883. ‡Savage, W. W. 109 St. James's-street, Brighton.
1883. ‡Savery, G. M., M.A. The College, Harrogate.
1872. *Sawyer, George David, F.R.M.S. 55 Buckingham-place, Brighton.
1887. §Sayce, Rev. A. H., M.A., D.D., Deputy-Professor of Comparative Philology in the University of Oxford. Queen's College, Oxford.
1884. ‡Sayre, Robert H. Bethlehem, Pennsylvania, U.S.A.
1883. *Scarborough, George. Holly Bank, Halifax, Yorkshire.
1883. ‡*Scarisbrick, Charles. 5 Palace-gate, Kensington, London, W.*
1884. ‡Scarth, William Bain. Winnipeg, Manitoba, Canada.
1868. §Schacht, G. F. 1 Windsor-terrace, Clifton, Bristol.
1879. *Schäfer, E. A., F.R.S., M.R.C.S., Professor of Physiology in University College, London. Croxley Green, Rickmansworth.
1883. ‡Schäfer, Mrs. Croxley Green, Rickmansworth.
1888. §Scharff, Robert F., Ph.D., B.Sc. Science and Art Museum, Dublin.
1880. *Schemmann, Louis Carl. Hamburg. (Care of Messrs. Allen Everitt & Sons, Birmingham.)

Year of Election.

1842. Schofield, Joseph. Stubley Hall, Littleborough, Lancashire.
1887. ‡Schofield, T. Thornfield, Talbot-road, Old Trafford, Manchester.
1883. ‡Schofield, William. Alma-road, Birkdale, Southport.
1885. §Scholes, L. Holly Bank, 19 Cleveland-road, Higher Crumpsall, near Manchester.
1888. ‡Scholey, J. Cranefield. 30 Sussex-villas, Kensington, London, W.
1887. §Schorlemmer, Carl, LL.D., F.R.S., Professor of Organic Chemistry in the Owens College, Manchester.
Schunck, Edward, Ph.D., F.R.S., F.C.S. Oaklands, Kersal Moor, Manchester.
1873. *Schuster, Arthur, Ph.D., F.R.S., F.R.A.S., Professor of Physics in the Owens College, Manchester.
1861. *Schwabe, Edmund Salis. Ryecroft House, Cheetham Hill, Manchester.
1887. ‡Schwabe, Colonel G. Salis. Portland House, Higher Crumpsall, Manchester.
1847. *Sclater, Philip Lutley, M.A., Ph.D., F.R.S., F.L.S., F.G.S., F.R.G.S., Sec.Z.S. 3 Hanover-square, London, W.
1883. *Sclater, William Lutley, B.A., F.Z.S. 3 Hanover-square, London, W.
1867. ‡Scott, Alexander. Clydesdale Bank, Dundee.
1881. *Scott, Alexander, M.A., D.Sc. 4 North Bailey, Durham.
1882. ‡Scott, Colonel A. de C., R.E. Ordnance Survey Office, Southampton.
1878. *Scott, Arthur William, M.A., Professor of Mathematics and Natural Science in St. David's College, Lampeter.
1881. ‡Scott, Miss Charlotte Angus. Lancashire College, Whalley Range, Manchester.
1889. §Scott, D. H., M.A., Ph.D., F.L.S. The Laurels, Bickley, Kent.
1885. ‡Scott, George Jamieson. Bayview House, Aberdeen.
1886. ‡Scott, Robert. 161 Queen Victoria-street, London, E.C.
1857. *Scott, Robert H., M.A., F.R.S., F.G.S., F.R.Met.S., Secretary to the Council of the Meteorological Office. 6 Elm Park-gardens, London, S.W.
1861. §Scott, Rev. Robert Selkirk, D.D. 16 Victoria-crescent, Dowanhill, Glasgow.
1884. *Scott, Sydney C. 15 Queen-street, Cheapside, London, E.C.
1869. ‡Scott, William Bower. Chudleigh, Devon.
1885. ‡*Scott-Moncrieff, W. G. The Castle, Banff.*
1881. *Scrivener, A. P. Haglis House, Wendover.
1883. ‡Scrivener, Mrs. Haglis House, Wendover.
1859. ‡Seaton, John Love. The Park, Hull.
1880. ‡Sedgwick, Adam, M.A., F.R.S. Trinity College, Cambridge.
1880. ‡Seebohm, Henry, F.L.S., F.Z.S. 6 Tenterden-street, Hanover-square, London, W.
1861. *Seeley, Harry Govier, F.R.S., F.L.S., F.G.S., F.R.G.S., F.Z.S., Professor of Geography in King's College, London. The Vine, Sevenoaks.
1855. ‡Seligman, H. L. 27 St. Vincent-place, Glasgow.
1879. §Selim, Adolphus. 21 Mincing-lane, London, E.C.
1885. §Semple, Dr. United Service Club, Edinburgh.
1887. §Semple, James C., M.R.I.A. 64 Grosvenor-road, Rathmines, Dublin.
1873. ‡Semple, R. H., M.D. 8 Torrington-square, London, W.C.
1888. §Senier, Alfred, M.D., Ph.D., F.C.S. Thornfield, Harold-road, London, S.E.
1858. *Senior, George, F.S.S. Old Whittington, Chesterfield.
1888. *Sennett, Alfred R., A.M.Inst.C.E. 1 Temple-gardens, London, E.C.
1870. *Sephton, Rev. J. 90 Huskisson-street, Liverpool.

Year of Election.

1883. §Seville, Miss M. A. Blythe House, Southport.
1875. §Seville, Thomas. Blythe House, Southport.
1868. ‡Sewell, Philip E. Catton, Norwich.
1888. §Shackles, Charles F. Hornsea, near Hull.
1883. ‡Shadwell, John Lancelot. 17 St. Charles-square, Ladbroke Grove-road, London, W.
1871. *Shand, James. Parkholme, Elm Park-gardens, London, S.W.
1867. ‡Shanks, James. Dens Iron Works, Arbroath, N.B.
1881. ‡Shann, George, M.D. Petergate, York.
1869. *Shapter, Dr. Lewis, LL.D. 1 Barnfield-crescent, Exeter.
1878. ‡Sharp, David, M.B. Bleckley, Shirley Warren, Southampton.
Sharp, Rev. John, B.A. Horbury, Wakefield.
1886. ‡Sharp, T. B. French Walls, Birmingham.
*Sharp, William, M.D., F.R.S., F.G.S. Horton House, Rugby.
Sharp, Rev. William, B.A. Mareham Rectory, near Boston, Lincolnshire.
1883. ‡Sharples, Charles H., F.C.S. 7 Fishergate, Preston.
1870. ‡Shaw, Duncan. Cordova, Spain.
1865. ‡Shaw, George. Cannon-street, Birmingham.
1881. *Shaw, H. S. Hele, M.Inst.C.E., Professor of Engineering in University College, Liverpool.
1887. *Shaw, James B. Holly Bank, Cornbrook, Manchester.
1870. ‡Shaw, John. 21 St. James's-road, Liverpool.
1845. ‡Shaw, John, M.D., F.L.S., F.G.S. Viatoris Villa, Boston, Lincolnshire.
1887. §Shaw, Saville. College of Science, Newcastle-upon-Tyne.
1883. *Shaw, W. N., M.A. Emmanuel House, Cambridge.
1883. ‡Shaw, Mrs. W. N. Emmanuel House, Cambridge.
1883. ‡*Sheard, J. 42 Hoghton-street, Southport.*
1884. ‡Sheldon, Professor J. P. Downton College, near Salisbury.
1878. §Shelford, William, M.Inst.C.E. 35a Great George-street, Westminster, S.W.
1865. ‡Shenstone, Frederick S. Sutton Hall, Barcombe, Lewes.
1881. ‡Shenstone, W. A. Clifton College, Bristol.
1885. ‡Shepherd, Rev. Alexander. Ecclesmechen, Uphall, Edinburgh.
1863. ‡*Shepherd, A. B. 17 Great Cumberland-place, Hyde Park, London, W.*
1885. ‡Shepherd, Charles. 1 Wellington-street, Aberdeen.
1883. ‡Shepherd, James. Birkdale, Southport.
1883. §Sherlock, David. Lower Leeson-street, Dublin.
1883. §Sherlock, Mrs. David. Lower Leeson-street, Dublin.
1883. ‡Sherlock, Rev. Edgar. Bentham Rectory, *viâ* Lancaster.
1888. *Shickle, Rev. C. W., M.A. Langridge Rectory, Bath.
1886. ‡Shield, Arthur H. 35a Great George-street, London, S.W.
1883. *Shillitoe, Buxton, F.R.C.S. 2 Frederick-place, Old Jewry, London, E.C.
1867. ‡Shinn, William C. 4 Varden's-road, Clapham Junction, Surrey, S.W.
1887. *Shipley, Arthur E., M.A. Christ's College, Cambridge.
1889. §Shipley, J. A. D. Saltwell Park, Gateshead.
1885. ‡Shirras, G. F. 16 Carden-place, Aberdeen.
1883. ‡Shone, Isaac. Pentrefelin House, Wrexham.
1870. *Shoolbred, James N., M.Inst.C.E., F.G.S. 1 Westminster-chambers, London, S.W.
1888. §Shoppee, C. H. 22 John-street, Bedford-row, London, W.C.
1888. §Shoppee, G. A., M.A., LL.M. 61 Doughty-street, London, W.C.
1875. ‡Shore, Thomas W., F.C.S., F.G.S. Hartley Institution, Southampton.

Year of Election.

1882. ‡SHORE, T. W., M.D., B.Sc., Lecturer on Comparative Anatomy at St. Bartholomew's Hospital. 13 Hill Side, Crouch Hill, London, N.

1881. ‡*Shuter, James L. 9 Steele's-road, Haverstock Hill, London, N.W.*

1889. §Sibley, Walter K., B.A., M.B. 7 Harley-street, London, W.

1883. ‡Sibly, Miss Martha Agnes. Flook House, Taunton.

1883. *Sidebotham, Edward John. Erlesdene, Bowdon, Cheshire.

1883. *Sidebotham, James Nasmyth. Parkfield, Altrincham, Cheshire.

1877. *Sidebotham, Joseph Watson. Erlesdene, Bowdon, Cheshire.

1885. *SIDGWICK, HENRY, M.A., Litt.D., Professor of Moral Philosophy in the University of Cambridge. Hillside, Chesterton-road, Cambridge.

Sidney, M. J. F. Cowpen, Newcastle-upon-Tyne.

1873. *Siemens, Alexander. 7 Airlie-gardens, Campden Hill, London, W.

1878. ‡Sigerson, Professor George, M.D., F.L.S., M.R.I.A. 3 Clare-street, Dublin.

1859. ‡Sim, John. Hardgate, Aberdeen.

1871. ‡Sime, James. Craigmount House, Grange, Edinburgh.

1862. ‡Simms, James. 138 Fleet-street, London, E.C.

1874. ‡Simms, William. The Linen Hall, Belfast.

1876. ‡Simon, Frederick. 24 Sutherland-gardens, London, W.

1887. *Simon, Henry. Darwin House, Didsbury.

1847. ‡Simon, Sir John, K.C.B., D.C.L., F.R.S., F.R.C.S., Consulting Surgeon to St. Thomas's Hospital. 40 Kensington-square, London, W.

1866. ‡Simons, George. The Park, Nottingham.

1871. *SIMPSON, ALEXANDER R., M.D., Professor of Midwifery in the University of Edinburgh. 52 Queen-street, Edinburgh.

1883. ‡Simpson, Byron R. 7 York-road, Birkdale, Southport.

1887. ‡Simpson, F. Estacion Central, Buenos Ayres.

1867. ‡Simpson, G. B. Seafield, Broughty Ferry, by Dundee.

1859. ‡Simpson, John. Maykirk, Kincardineshire.

1863. ‡Simpson, J. B., F.G.S. Hedgefield House, Blaydon-on-Tyne.

1857. ‡SIMPSON, MAXWELL, M.D., LL.D., F.R.S., F.C.S., Professor of Chemistry in Queen's College, Cork.

1883. ‡Simpson, Walter M. 7 York-road, Birkdale, Southport.

Simpson, William. Bradmore House, Hammersmith, London, W.

1884. **Simpson, W. J. R., M.D. Town House, Aberdeen.*

1887. ‡Sinclair, Dr. 268 Oxford-street, Manchester.

1874. ‡Sinclair, Thomas. Dunedin, Belfast.

1870. *Sinclair, W. P., M.P. Rivelyn, Prince's Park, Liverpool.

1864. *Sircar, The Hon. Mahendra Lal, M.D., C.I.E. 51 Sankaritola, Calcutta.

1865. ‡Sissons, William. 92 Park-street, Hull.

1879. ‡Skertchly, Sydney B. J., F.G.S. 3 Loughborough-terrace, Carshalton, Surrey.

1883. ‡Skillicorne, W. N. 9 Queen's-parade, Cheltenham.

1885. ‡Skinner, Provost. Inverurie, N.B.

1888. §SKRINE, H. D., J.P., D.L. Claverton Manor, Bath.

1870. §SLADEN, WALTER PERCY, F.G.S., F.L.S. Orsett House, Ewell, Surrey.

1873. ‡Slater, Clayton. Barnoldswick, near Leeds.

1889. §Slater, Matthew B., F.L.S. Malton, Yorkshire.

1842. *Slater, William. Park-lane, Higher Broughton, Manchester.

1884. ‡Slattery, James W. 9 Stephen's-green, Dublin.

1877. ‡Sleeman, Rev. Philip, L.Th., F.R.A.S., F.G.S. Clifton, Bristol.

1884. ‡Slooten, William Venn. Nova Scotia, Canada.

Year of Election.

1849. ‡Sloper, George Elgar. Devizes.
1860. ‡Sloper, S. Elgar. Winterton, near Hythe, Southampton.
1867. ‡Small, David. Gray House, Dundee.
1887. §Small, E. W. 11 Arthur-street, Nottingham.
1887. §Small, William. Cavendish-crescent North, The Park, Nottingham.
1881. ‡Smallshan, John. 81 Manchester-road, Southport.
1885. §Smart, James. Valley Works, Brechin, N.B.
1889. *Smart, William. Nunholme, Dowanhill, Glasgow.
1858. ‡Smeeton, G. H. Commercial-street, Leeds.
1876. §Smellie, Thomas D. 213 St. Vincent-street, Glasgow.
1877. ‡Smelt, Rev. Maurice Allen, M.A., F.R.A.S. Heath Lodge, Cheltenham.
1876 ‡Smieton, James. Panmure Villa, Broughty Ferry, Dundee.
1876. ‡Smieton, John G. 3 Polworth-road, Coventry Park, Streatham, London, S.W.
1867. ‡Smieton, Thomas A. Panmure Villa, Broughty Ferry, Dundee.
1857. ‡Smith, Aquilla, M.D., M.R.I.A. 121 Lower Baggot-street, Dublin.
1872. *Smith, Basil Woodd, F.R.A.S. Branch Hill Lodge, Hampstead Heath, London, N.W.
1874. *Smith, Benjamin Leigh, F.R.G.S. Oxford and Cambridge Club, Pall Mall, London, S.W.
1887. ‡Smith, Bryce. Rye Bank, Chorlton-cum-Hardy, Manchester.
1873. ‡Smith, C. Sidney College, Cambridge.
1887. *Smith, Charles. 739 Rochdale-road, Manchester.
1889. *Smith, C. Michie, B.Sc., F.R.S.E., F.R.A.S. Madras.
1865. ‡SMITH, DAVID, F.R.A.S. 40 Bennett's-hill, Birmingham.
1886. ‡Smith, Edwin. 33 Wheeley's-road, Edgbaston, Birmingham.
1886. ‡Smith, E. Fisher, J.P. The Priory, Dudley.
1886. ‡Smith, E. O. Council House, Birmingham.
1866. *Smith, F. C. Bank, Nottingham.
1887. §Smith, Rev. F. J., M.A. Trinity College, Oxford.
1855. ‡*Smith, George. Port Dundas, Glasgow.*
1885. ‡Smith, Rev. G. A., M.A. 91 Fountainhall-road, Aberdeen.
1860. *Smith, Heywood, M.A., M.D. 18 Harley-street, Cavendish-square, London, W.
1870. ‡Smith, H. L. Crabwall Hall, Cheshire.
1889. *Smith, H. Llewellyn, B.A., B.Sc., F.S.S. 49 Beaumont-square, London, E.
1888. ‡Smith, H. W. Owens College, Manchester.
1885. ‡Smith, Rev. James, B.D. Manse of Newhills, N.B.
1876. *Smith, J. Guthrie. 54 West Nile-street, Glasgow.
1874. ‡*Smith, John Haigh. 77 Southbank-road, Southport.*
Smith, John Peter George. Sweyney Cliff, Coalport, Iron Bridge, Shropshire.
1871. ‡Smith, J. William Robertson, M.A., Lord Almoner's Professor of Arabic in the University of Cambridge.
1883. ‡Smith, M. Holroyd. Fern Hill, Halifax.
1886. *Smith, Mrs. Hencotes House, Hexham.
1837. Smith, Richard Bryan. Villa Nova, Shrewsbury.
1885. ‡SMITH, ROBERT H., M.Inst.C.E., Professor of Engineering in the Mason Science College, Birmingham.
1840. *Smith, Robert Mackay. 4 Bellevue-crescent, Edinburgh.
1870. ‡Smith, Samuel. Bank of Liverpool, Liverpool.
1866. ‡Smith, Samuel. 33 Compton-street, Goswell-road, London, E.C.
1873. ‡Smith, Swire. Lowfield, Keighley, Yorkshire.
1867. ‡Smith, Thomas. Dundee.
1867. ‡Smith, Thomas. Poole Park Works, Dundee.

Year of Election.

1859. ‡Smith, Thomas James, F.G.S., F.C.S. Hornsea Burton, East Yorkshire.
1884. ‡Smith, Vernon. 127 Metcalfe-street, Ottawa, Canada.
1885. *Smith, Watson. University College, London, W.C.
1887. §Smith, Dr. Wilberforce. 14 Stratford-place, London, W.
1852. ‡Smith, William. Eglinton Engine Works, Glasgow.
1875. *Smith, William. Sundon House, Clifton, Bristol.
1876. ‡Smith, William. 12 Woodside-place, Glasgow.
1883. ‡Smithells, Arthur, B.Sc., Professor of Chemistry in the Yorkshire College, Leeds.
1883. ‡Smithson, Edward Walter. 13 Lendal, York.
1883. ‡Smithson, Mrs. 13 Lendal, York.
1878. ‡Smithson, Joseph S. Balnagowan, Rathmines, Co. Dublin.
1882. ‡Smithson, T. Spencer. Facit, Rochdale.
1874. ‡Smoothy, Frederick. Bocking, Essex.
1850. *Smyth, Charles Piazzi, F.R.S.E., F.R.A.S. Clova, Ripon.
1883. ‡Smyth, Rev. Christopher. The Vicarage, Bussage, Stroud.
1874. ‡Smyth, Henry. Downpatrick, Ireland.
1878. §Smyth, Mrs. Isabella. Wigmore Lodge, Cullenswood-avenue, Dublin.
1857. *Smyth, John, jun., M.A., F.C.S., F.R.M.S., M.Inst.C.E.I. Milltown, Banbridge, Ireland.
1864. ‡Smyth, Sir Warington W., M.A., F.R.S., F.G.S., F.R.G.S., Lecturer on Mining at the Royal School of Mines, and Inspector of the Mineral Property of the Crown. 5 Inverness-terrace, Bayswater, London, W.
1888. *Snape, H. Lloyd, D.Sc., Ph.D., F.C.S., Professor of Chemistry in University College, Aberystwith.
1888. ‡Snell, Albion T. Messrs. Immisch & Co., London.
1887. ‡Snell, Bernard J. 5 Park-place, Broughton, Manchester.
1878. §Snell, H. Saxon. 22 Southampton-buildings, London, W.C.
1889. §Snell, W. H. Lamorna, Oxford-road, Putney, S.W.
1879. *Sollas, W. J., M.A., D.Sc., F.R.S., F.R.S.E., F.G.S., Professor of Geology in the University of Dublin. Trinity College, Dublin.
Sorbey, Alfred. The Rookery, Ashford, Bakewell.
1859. *Sorby, H. Clifton, LL.D., F.R.S., F.G.S. Broomfield, Sheffield.
1879. *Sorby, Thomas W. Storthfield, Sheffield.
1888. ‡Sorley, Professor W. R. University College, Cardiff.
1886. ‡Southall, Alfred. Carrick House, Richmond Hill-road, Birmingham.
1865. *Southall, John Tertius. Parkfields, Ross, Herefordshire.
1859. ‡Southall, Norman. 44 Cannon-street West, London, E.C.
1887. §Sowerbutts, Eli, F.R.G.S. 44 Brown-street, Manchester.
1883. ‡Spanton, William Dunnett, F.R.C.S. Chatterley House, Hanley, Staffordshire.
1863. *Spark, H. King, F.G.S. Startforth House, Barnard Castle.
1889. §Spence, Faraday. 67 Grey-street, Hexham.
1869. *Spence, J. Berger. 31 Lombard-street, London, E.C.
1887. §Spencer, F. M. Fernhill, Knutsford.
1881. ‡Spencer, Herbert E. Lord Mayor's Walk, York.
1884. §Spencer, John, M.Inst.M.E. Globe Tube Works, Wednesbury.
1889. *Spencer, John. Newburn, Newcastle-upon-Tyne.
1861. ‡Spencer, John Frederick. 28 Great George-street, London, S.W.
1861. **Spencer, Joseph. Springbank, Old Trafford, Manchester.*
1863. *Spencer, Thomas. The Grove, Ryton, Blaydon-on-Tyne, Co. Durham.
1875. ‡*Spencer, W. H. Richmond Hill, Clifton, Bristol.*
1884. *Spice, Robert Paulson, M.Inst.C.E. 21 Parliament-street, Westminster, S.W.

Year of Election.

1864. *Spicer, Henry, B.A., F.L.S., F.G.S. 14 Aberdeen Park, Highbury, London, N.
1864. *Spiller, John, F.C.S. 2 St. Mary's-road, Canonbury, London, N.
1878. §Spottiswoode, George Andrew. 3 Cadogan-square, London, S.W.
1864. *Spottiswoode, W. Hugh, F.C.S. 41 Grosvenor-place, London, S.W.
1854. *Sprague, Thomas Bond, M.A., F.R.S.E. 26 St. Andrew-square, Edinburgh.
1883. §Spratling, W. J., B.Sc., F.G.S. Maythorpe, 74 Wickham-road, Brockley, S.E.
1853. ‡*Spratt, Joseph James. West-parade, Hull.*
1888. §Spreat, John Henry. Care of Messrs. Vines & Froom, 75 Aldersgate-street, London, E.C.
1884. *Spruce, Samuel. Beech House, Tamworth.
Square, Joseph Elliot. 147 Maida Vale, London, W.
1877. ‡Square, William, F.R.C.S., F.R.G.S. 4 Portland-square, Plymouth.
*Squire, Lovell. 6 Heathfield-terrace, Chiswick, Middlesex.
1888. *Stacy, J. Sargeant. 7 and 8 Paternoster-row, London, E.C.
1879. ‡Stacye, Rev. John. Shrewsbury Hospital, Sheffield.
1858. *Stainton, Henry T., F.R.S., F.L.S., F.G.S. Mountsfield, Lewisham, S.E.
1884. ‡Stancoffe, Frederick. Dorchester-street, Montreal, Canada.
1883. *Stanford, Edward, jun., F.R.G.S. Thornbury, Bromley, Kent.
1865. ‡Stanford, Edward C. C., F.C.S. Glenwood, Dalmuir, N.B.
1881. *Stanley, William Ford, F.G.S. Cumberlow, South Norwood, Surrey, S.E.
1883. ‡Stanley, Mrs. Cumberlow, South Norwood, Surrey, S.E.
Stapleton, M. H., M.B., M.R.I.A. 1 Mountjoy-place, Dublin.
1883. ‡Stapley, Alfred M. Marion-terrace, Crewe.
1866. ‡*Starey, Thomas R. Daybrook House, Nottingham.*
1876. ‡Starling, John Henry, F.C.S. The Avenue, Erith, Kent.
Staveley, T. K. Ripon, Yorkshire.
1873. *Stead, Charles. Saltaire, Bradford, Yorkshire.
1881. ‡Stead, W. H. Orchard-place, Blackwall, London, E.
1881. ‡Stead, Mrs. W. H. Orchard-place, Blackwall, London, E.
1884. ‡Stearns, Sergeant P. U.S. Consul-General, Montreal, Canada.
1873. ‡Steinthal, G. A. 15 Hallfield-road, Bradford, Yorkshire.
1887. ‡Steinthal, S. Alfred. 81 Nelson-street, Manchester.
1887. ‡Stelfox, John L. 6 Hilton-street, Oldham, Manchester.
1884. ‡Stephen, George. 140 Drummond-street, Montreal, Canada.
1884. ‡Stephen, Mrs. George. 140 Drummond-street, Montreal, Canada.
1884. *Stephens, W. Hudson. Lowville (P.O.), State of New York, U.S.A.
1879. *Stephenson, Henry, J.P. Endcliffe Vale, Sheffield.
1870. *Stevens, Miss Anna Maria. 1 Sinclair-road, West Kensington, London, W.
1880. *Stevens, J. Edward. 16 Woodlands-terrace, Swansea.
1886. ‡Stevens, Marshall. Highfield House, Urmston, near Manchester.
1878. ‡*Stevenson, Rev. James, M.A. 21 Garville-avenue, Rathgar, Dublin.*
1863. *Stevenson, James C., M.P., F.C.S. Westoe, South Shields.
1889. §Stevenson, T. Shannon. Westoe, South Shields.
1887. **Stewart, A. H. Heather-lane, Bowdon, Manchester.*
1882. ‡Steward, Rev. C. E., M.A. The Polygon, Southampton.
1885. ‡Stewart, Rev. Alexander, M.D., LL.D. Heathcot, Aberdeen.
1864. ‡Stewart, Charles, M.A., F.L.S. St. Thomas's Hospital, London, S.E.
1885. ‡Stewart, David. Banchory House, Aberdeen.
1886. *Stewart, Duncan. 12 Montgomerie-crescent, Kelvinside, Glasgow.

Year of Election.

1887. ‡Stewart, George N. Physiological Laboratory, Owens College, Manchester.
1875. *Stewart, James, B.A., F.R.C.P.Ed. Dunmurry, Sneyd Park, near Clifton, Gloucestershire.
1876. ‡Stewart, William. Violet Grove House, St. George's-road, Glasgow.
1867. ‡Stirling, Dr. D. Perth.
1876. ‡STIRLING, WILLIAM, M.D., D.Sc., F.R.S.E., Professor of Physiology in the Owens College, Manchester.
1867. *Stirrup, Mark, F.G.S. Stamford-road, Bowdon, Cheshire.
1865. *Stock, Joseph S. St. Mildred's, Walmer.
1883. *STOCKER, W. R. Cooper's Hill, Staines.
1854. ‡Stoess, Le Chevalier Ch. de W. (Bavarian Consul). Liverpool.
1845. *STOKES, Sir GEORGE GABRIEL, Bart., M.P., M.A., D.C.L., LL.D., D.Sc., Pres. R.S., Lucasian Professor of Mathematics in the University of Cambridge. Lensfield Cottage, Cambridge.
1887. ‡Stone, E. D., F.C.S. The Depleach, Cheadle, Cheshire.
1862. ‡STONE, EDWARD JAMES, M.A., F.R.S., F.R.A.S., Director of the Radcliffe Observatory, Oxford.
1886. ‡Stone, J. B. The Grange, Erdington, Birmingham.
1886. ‡Stone, J. H. Grosvenor-road, Handsworth, Birmingham.
1874. ‡Stone, J. Harris, M.A., F.L.S., F.C.S. 11 Sheffield-gardens, Kensington, London, W.
1888. ‡STONE, JOHN. 15 Royal-crescent, Bath.
1876. ‡*Stone, Octavius C., F.R.G.S. Springfield, Nuneaton.*
1883. §Stone, Thomas William. 189 Goldhawk-road, Shepherd's Bush, London, W.
1859. ‡STONE, Dr. WILLIAM H. 14 Dean's-yard, Westminster, S.W.
1857. ‡STONEY, BINDON B., LL.D., F.R.S., M.Inst.C.E., M.R.I.A., Engineer of the Port of Dublin. 14 Elgin-road, Dublin.
1878. *Stoney, G. Gerald. 9 Palmerston Park, Dublin.
1861. *STONEY, GEORGE JOHNSTONE, M.A., D.Sc., F.R.S., M.R.I.A. 9 Palmerston Park, Dublin.
1876. §Stopes, Henry, F.G.S. Kenwyn, Cintra Park, Upper Norwood, S.E.
1883. §Stopes, Mrs. Kenwyn, Cintra Park, Upper Norwood, S.E.
1887. ‡Storer, Edwin. Woodlands, Crumpsall, Manchester.
1887. *Storey, H. L. Caton, near Lancaster.
1873. ‡Storr, William. The 'Times' Office, Printing-house-square, London, E.C.
1884. §Storrs, George H. Fern Bank, Stalybridge.
1859. §Story, Captain James Hamilton. 17 Bryanston-square, London, W.
1888. ‡STOTHERT, J. L., M.Inst.C.E. Audley, Park-gardens, Bath.
1888. *Stothert, Percy K. Audley, Park-gardens, Bath.
1874. ‡Stott, William. Scar Bottom, Greetland, near Halifax, Yorkshire.
1871. *STRACHEY, Lieut.-General RICHARD, R.E., C.S.I., F.R.S., F.R.G.S., F.L.S., F.G.S. 69 Lancaster-gate, Hyde Park, London, W.
1881. ‡Strahan, Aubrey, M.A., F.G.S. Geological Museum, Jermyn-street, London, S.W.
1876. ‡Strain, John. 143 West Regent-street, Glasgow.
1863. ‡Straker, John. Wellington House, Durham.
1889. §Straker, Captain Joseph. Dilston House, Riding Mill-on-Tyne.
1882. ‡Strange, Rev. Cresswell, M.A. Edgbaston Vicarage, Birmingham.
1881. ‡Strangways, C. Fox, F.G.S. Geological Museum, Jermyn-street, London, S.W.
1889. §Streatfield, H. S. The Limes, Leigham Court-road, Streatham, S.W.
*Strickland, Charles. 21 Fitzwilliam-place, Dublin.
1879. ‡Strickland, Sir Charles W., K.C.B. Hildenley-road, Malton.

Year of Election.

1884. ‡Stringham, Irving. The University, Berkeley, California, U.S.A.
1859. ‡Stronach, William, R.E. Ardmellie, Banff.
1883. §Strong, Henry J., M.D. Whitgift House, Croydon.
1867. ‡Stronner, D. 14 Princess-street, Dundee.
1887. *Stroud, Professor H., M.A., D.Sc., College of Science, Newcastle-upon-Tyne.
1887. *Stroud, William, D.Sc., Professor of Physics in the Yorkshire College, Leeds.
1876. *STRUTHERS, JOHN, M.D., LL.D. Aberdeen.
1878. ‡Strype, W. G. Wicklow.
1876. *Stuart, Charles Maddock. High School, Newcastle, Staffordshire.
1872. *Stuart, Rev. Edward A., M.A. 116 Grosvenor-road, Highbury New Park, London, N.
1886. ‡Stuart, G. Morton, M.A. East Harptree, near Bristol.
1884. ‡Stuart, Dr. W. Theophilus. 183 Spadina-avenue, Toronto, Canada.
1888. *Stubbs, Rev. Elias T., M.A. 4 Springfield-place, Bath.
1885. §Stump, Edward C. 26 Parkfield-street, Moss-lane East, Manchester.
1879. *Styring, Robert. 3 Hartshead, Sheffield.
Sulivan, H. N., F.R.G.S. King-street, Newcastle-upon-Tyne.
1857. ‡SULLIVAN, WILLIAM K., Ph.D., M.R.I.A. Queen's College, Cork.
1883. ‡Summers, William, M.P. Sunnyside, Ashton-under-Lyne.
1884. ‡Sumner, George. 107 Stanley-street, Montreal, Canada.
1887. ‡Sumpner, W. E. 37 Pennyfields, Poplar, London, E.
1888. ‡Sunderland, John E. Bark House, Hatherlow, Stockport.
1883. ‡Sutcliffe, J. S., J.P. Beech House, Bacup.
1873. ‡Sutcliffe, J. W. Sprink Bank, Bradford, Yorkshire.
1873. ‡Sutcliffe, Robert. Idle, near Leeds.
1863. ‡Sutherland, Benjamin John. Thurso House, Newcastle-upon-Tyne.
1862. *SUTHERLAND, GEORGE GRANVILLE WILLIAM, Duke of, K.G., F.R.S., F.R.G.S. Stafford House, London, S.W.
1886. ‡Sutherland, Hugh. Winnipeg, Manitoba, Canada.
1884. ‡Sutherland, J. C. Richmond, Quebec, Canada.
1863. ‡SUTTON, FRANCIS, F.C.S. Bank Plain, Norwich.
1881. ‡Sutton, William. Town Hall, Southport.
1889. §Sutton, William. Esbank, Jesmond, Newcastle-upon-Tyne.
1881. ‡Swales, William. Ashville, Holgate Hill, York.
1876. ‡Swan, David, jun. Braeside, Maryhill, Glasgow.
1881. ‡Swan, Joseph Wilson, M.A. Lauriston, Bromley, Kent.
1861. *Swan, Patrick Don S. Kirkcaldy, N.B.
1862. *SWAN, WILLIAM, LL.D., F.R.S.E., Professor of Natural Philosophy in the University of St. Andrews, N.B.
1879. ‡Swanwick, Frederick. Whittington, Chesterfield.
1883. ‡Sweeting, Rev. T. E. 50 Roe-lane, Southport.
1887. §Swinburne, James. Shona, Chelmsford.
1870. *Swinburne, Sir John, Bart., M.P. Capheaton, Newcastle-upon-Tyne.
1885. ‡Swindells, Miss. Springfield House, Ilkley, Yorkshire.
1887. *Swindells, Rupert, F.R.G.S. Wilton Villa, The Firs, Bowdon, Cheshire.
1873. *Swinglehurst, Henry. Hincaster House, near Milnthorpe.
1889. §Sworn, Sidney C. 152 Railton-road, Herne Hill, London, S.E.
1858. ‡SYDNEY, The Right Rev. ALFRED BARRY, Bishop of, D.D., D.C.L. Sydney.
1883. ‡Sykes, Alfred. Highfield, Huddersfield.
1873. §Sykes, Benjamin Clifford, M.D. St. John's House, Cleckheaton.
1887. *Sykes, George H., M.A., M.Inst.C.E., F.S.A. 12 Albert-square, Clapham, London, S.W.
1862. ‡Sykes, Thomas. Cleckheaton.

Year of Election.

1887. *Sykes, T. H. Cheadle, Cheshire.
Sylvester, James Joseph, M.A., D.C.L., LL.D., F.R.S., Savilian Professor of Geometry in the University of Oxford. Oxford.
1870. ‡Symes, Richard Glascott, B.A., F.G.S., Geological Survey of Ireland. 14 Hume-street, Dublin.
1885. ‡Symington, Johnson, M.D. 2 Greenhill Park, Edinburgh.
1881. *Symington, Thomas. Wardie House, Edinburgh.
1856. *Symonds, Frederick, M.A., F.R.C.S. 35 Beaumont-street, Oxford.
1859. §Symons, G. J., F.R.S., Sec.R.Met.Soc. 62 Camden-square, London, N.W.
1883. †*Symons, Simon. Belfast House, Farquhar-road, Norwood, S.E.*
1855. *Symons, William, F.C.S. Dragon House, Bilbrook, near Taunton.
1886. §Symons, W. H., F.C.S., F.R.Met.S. 130 Fellowes-road, Hampstead, London, N.W.
1872. ‡Synge, Major-General Millington, R.E., F.S.A., F.R.G.S. United Service Club, Pall Mall, London, S.W.

1865. ‡Tailyour, Colonel Renny, R.E. Newmanswalls, Montrose, N.B.
1877. *Tait, Lawson, F.R.C.S. The Crescent, Birmingham.
1871. ‡Tait, Peter Guthrie, F.R.S.E., Professor of Natural Philosophy in the University of Edinburgh. George-square, Edinburgh.
1867. ‡Tait, P. M., F.R.G.S., F.S.S. Hardwicke House, Hardwicke-road, Eastbourne.
1883. §Tapscott, R. L. 41 Parkfield-road, Prince's Park, Liverpool.
1878. ‡Tarpey, Hugh. Dublin.
1861. *Tarratt, Henry W. Moseley, Owl's-road, Boscombe, Bournemouth.
1857. *Tate, Alexander. Longwood, Whitehouse, Belfast.
1870. ‡Tate, Norman A. 7 Nivell-chambers, Fazackerley-street, Liverpool.
1858. *Tatham, George, J.P. Springfield Mount, Leeds.
1886. ‡Taunton, Richard. Brook Vale, Witton.
1878. *Taylor, A. Claude. North Circus-street, Nottingham.
1884. *Taylor, Rev. Charles, D.D. St. John's Lodge, Cambridge.
Taylor, Frederick. Laurel Cottage, Rainhill, near Prescot, Lancashire.
1887. §Taylor, G. H. Holly House, 235 Eccles New-road, Salford.
1874. ‡Taylor, G. P. Students' Chambers, Belfast.
1887. §Taylor, George Spratt, F.C.S. 13 Queen's-terrace, St. John's Wood, London, N.W.
1881. *Taylor, H. A. 25 Collingham-road, South Kensington, London, S.W.
1884. *Taylor, H. M., M.A. Trinity College, Cambridge.
1882. *Taylor, Herbert Owen, M.D. 17 Castlegate, Nottingham.
1887. ‡Taylor, Rev. Canon Isaac, D.D. Settrington Rectory, York.
1879. ‡Taylor, John. Broomhall-place, Sheffield.
1861. *Taylor, John, M.Inst.C.E., F.G.S. 29 Portman-square, London, W.
1873. ‡Taylor, John Ellor, Ph.D., F.L.S., F.G.S. The Mount, Ipswich.
1881. *Taylor, John Francis. Holly Bank House, York.
1865. ‡Taylor, Joseph. 99 Constitution-hill, Birmingham.
1883. ‡Taylor, Michael W., M.D. Hatton Hall, Penrith.
1876. ‡Taylor, Robert. 70 Bath-street, Glasgow.
1878. ‡*Taylor, Robert, J.P., LL.D. Corballis, Drogheda.*
1884. *Taylor, Miss S. Oak House, Shaw, near Oldham.
1881. ‡Taylor, Rev. S. B., M.A. Whixley Hall, York.
1883. ‡Taylor, S. Leigh. Birklands, Westcliffe-road, Birkdale, Southport.
1870. ‡Taylor, Thomas. Aston Rowant, Tetsworth, Oxon.

Year of Election.

1887. ‡Taylor, Tom. Grove House, Sale, Manchester.
1883. ‡Taylor, William, M.D. 21 Crockherbtown, Cardiff.
1884. ‡Taylor-Whitehead, Samuel, J.P. Burton Closes, Bakewell.
1858. ‡Teale, Thomas Pridgin, jun. 20 Park-row, Leeds.
1885. ‡Teall, J. J. H., M.A., F.G.S. 28 Jermyn-street, London, S.W.
1869. ‡*Teesdale, C. S. M. Whyke House, Chichester.*
1879. ‡Temple, Lieutenant George T., R.N., F.R.G.S. The Nash, near Worcester.
1880. §Temple, Sir Richard, Bart., G.C.S.I., C.I.E., D.C.L., LL.D., M.P., F.R.G.S. Athenæum Club, London, S.W.
1863. ‡Tennant, Henry. Saltwell, Newcastle-on-Tyne.
1889. §Tennant, James. Dartmoor Lodge, Gateshead.
1882. §Terrill, William. 42 St. George's-terrace, Swansea.
1881. ‡Terry, Mr. Alderman. Mount-villas, York.
1883. ‡Tetley, C. F. The Brewery, Leeds.
1883. ‡Tetley, Mrs. C. F. The Brewery, Leeds.
1887. ‡Tetlow, T. 273 Stamford-street, Ashton-under-Lyne.
1882. *Thane, George Dancer, Professor of Anatomy in University College. Gower-street, London, W.C.
1885. ‡Thin, Dr. George, 22 Queen Anne-street, London, W.
1871. ‡Thin, James. 7 Rillbank-terrace, Edinburgh.
1871. ‡Thiselton-Dyer, W. T., C.M.G., M.A., B.Sc., F.R.S., F.L.S. Royal Gardens, Kew.
1835. Thom, John. Lark-hill, Chorley, Lancashire.
1870. ‡Thom, Robert Wilson. Lark-hill, Chorley, Lancashire.
1871. ‡Thomas, Ascanius William Nevill. Chudleigh, Devon.
1875. *Thomas, Christopher James. Drayton Lodge, Redland, Bristol.
1883 ‡Thomas, Ernest C., B.A. 13 South-square, Gray's Inn, London, W.C.
1884. ‡Thomas, F. Wolferstan. Molson's Bank, Montreal, Canada.
Thomas, George. Brislington, Bristol.
1875. ‡Thomas, Herbert. Ivor House, Redland, Bristol.
1869. ‡Thomas, H. D. Fore-street, Exeter.
1881. §Thomas, J. Blount. Southampton.
1869. ‡Thomas, J. Henwood, F.R.G.S. Custom House, London, E.C.
1880. *Thomas, Joseph William, F.C.S. The Laboratory, West Wharf, Cardiff.
1883. ‡Thomas, P. Bossley. 4 Bold-street, Southport.
1883. §Thomas, Thomas H. 45 The Walk, Cardiff.
1883. ‡Thomas, William. Lan, Swansea.
1886. ‡Thomas, William. 109 Tettenhall-road, Wolverhampton.
1886. §Thomasson, Yeoville. 9 Observatory-gardens, Kensington, London, W.
1875. ‡Thompson, Arthur. 12 St. Nicholas-street, Hereford.
1887. §Thompson, C. St. Mary's Hospital, London, W.
1883. ‡Thompson, Miss C. E. Heald Bank, Bowdon, Manchester.
1882. ‡Thompson, Charles O. Terre Haute, Indiana, U.S.A.
1888. *Thompson, Claude M., M.A., Professor of Chemistry in University College, Cardiff.
1885. ‡Thompson, D'Arcy W., B.A., Professor of Physiology in University College, Dundee. University College, Dundee.
1883. *Thompson, Francis. Lynton, Haling Park-road, Croydon.
1859. ‡Thompson, George, jun. Pitmedden, Aberdeen.
Thompson, Harry Stephen. Kirby Hall, Great Ouseburn, Yorkshire.
1870. ‡Thompson, Sir Henry. 35 Wimpole-street, London, W.
1889. §Thompson, Henry. 2 Eslington-terrace, Newcastle-upon-Tyne.
1883. *Thompson, Henry G., M.D. 8 Addiscombe-villas, Croydon.
Thompson, Henry Stafford. Fairfield, near York.

Year of Election.

1883. *Thompson, Isaac Cooke, F.L.S., F.R.M.S. Woodstock, Waverley-road, Liverpool.
1861. *THOMPSON, JOSEPH. Riversdale, Wilmslow, Manchester.
1873. ‡Thompson, M. W. Guiseley, Yorkshire.
1876. *Thompson, Richard. Hob Moor, York.
1883. ‡Thompson, Richard. Bramley Mead, Whalley, Lancashire.
1874. ‡Thompson, Robert. Walton, Fortwilliam Park, Belfast.
1876. ‡THOMPSON, SILVANUS PHILLIPS, B.A., D.Sc., F.R.A.S., Professor of Physics in the City and Guilds of London Institute, Finsbury Technical Institute, E.C.
1884. ‡*Thompson, Sydney de Courcy.* 16 *Canonbury-park South, London, N.*
1883. *Thompson, T. H. Heald Bank, Bowdon, Manchester.
1863. ‡*Thompson, William.* 11 *North-terrace, Newcastle-upon-Tyne.*
1867. ‡Thoms, William. Magdalen-yard-road, Dundee.
Thomson, Guy. Oxford.
1850. *THOMSON, JAMES, M.A., LL.D., D.Sc., F.R.S. L. & E. 2 Florentine-gardens, Hillhead-street, Glasgow.
1889. *Thomson, James, jun., M.A. 2 Florentine-villas, Hillhead street, Glasgow.
1868. §THOMSON, JAMES, F.G.S. 26 Leven-street, Pollokshields, Glasgow.
1876. ‡Thomson, James R. Mount Blow, Dalmuir, Glasgow.
1883. ‡THOMSON, J. J., M.A., F.R.S., Professor of Experimental Physics in the University of Cambridge. Trinity College, Cambridge.
1871. *THOMSON, JOHN MILLAR, F.C.S., Professor of Chemistry in King's College, London, W.C.
1886. ‡Thomson, Joseph. Thornhill, Dumfries-shire.
1847. *THOMSON, Sir WILLIAM, M.A., LL.D., D.C.L., F.R.S. L. & E., F.R.A.S., Professor of Natural Philosophy in the University of Glasgow. The University, Glasgow.
1877. *Thomson, Lady. The University, Glasgow.
1874. §THOMSON, WILLIAM, F.R.S.E., F.C.S. Royal Institution, Manchester.
1880. §Thomson, William J. Ghyllbank, St. Helens.
1871. ‡Thornburn, Rev. David, M.A. 1 John's-place, Leith.
1852. ‡Thornburn, Rev. William Reid, M.A. Starkies, Bury, Lancashire.
1886. §Thornley, J. E. Lyndon, Bickenhill, near Birmingham.
1887. ‡Thornton, John. 3 Park-street, Bolton.
1867. ‡Thornton, Thomas. Dundee.
1883. §Thorowgood, Samuel. Castle-square, Brighton.
1845. ‡Thorp, Dr. Disney. Lypiatt Lodge, Suffolk Lawn, Cheltenham.
1881. ‡Thorp, Fielden. Blossom-street, York.
1871. ‡Thorp, Henry. Briarleigh, Sale, near Manchester.
1881. *Thorp, Josiah. 86 Canning-street, Liverpool.
1864. *Thorp, William, B.Sc., F.C.S. 24 Crouch Hall-road, Crouch End, London, N.
1871. ‡THORPE, T. E., Ph.D., F.R.S. L. & E., F.C.S., Professor of Chemistry in the Normal School of Science. Science Schools, South Kensington, London, S.W.
1883. §Threlfall, Henry Singleton. 5 Prince's-street, Southport.
1883. ‡Thresh, John C., D.Sc. The Willows, Buxton.
1868. ‡THUILLIER, General Sir H. E. L., R.A., C.S.I., F.R.S., F.R.G.S. Tudor House, Richmond Green, Surrey.
1889. §Thys, Captain Albert. 9 Rue Briderode, Brussels.
1870. ‡Tichborne, Charles R. C., LL.D., F.C.S., M.R.I.A. Apothecaries' Hall of Ireland, Dublin.
1873. *TIDDEMAN, R. H., M.A., F.G.S. 28 Jermyn-street, London, S.W.
1885. §TIDY, CHARLES MEYMOTT, M.D. 3 Mandeville-place, Cavendish-square, London, W.

Year of Election.

1874. ‡TILDEN, WILLIAM A., D.Sc., F.R.S., F.C.S., Professor of Chemistry and Metallurgy in the Mason Science College, Birmingham.
1873. ‡Tilghman, B. C. Philadelphia, U.S.A.
1883. ‡Tillyard, A. I., M.A. Fordfield, Cambridge.
1883. ‡Tillyard, Mrs. Fordfield, Cambridge.
1865. ‡Timmins, Samuel, J.P., F.S.A. Hill Cottage, Fillongley, Coventry.
1876. ‡Todd, Rev. Dr. Tudor Hall, Forest Hill, London, S.E.
1889. §Toll, John M. Monkton Lodge, Anfield, Liverpool.
1887. ‡Tolmé, Mrs. Melrose House, Higher Broughton, Manchester.
1857. ‡Tombe, Rev. Canon. Glenealy, Co. Wicklow.
1888. ‡Tomkins, Rev. Henry George. Park Lodge, Weston-super-Mare.
1864. *TOMLINSON, CHARLES, F.R.S., F.C.S. 7 North-road, Highgate, London, N.
1887. ‡Tonge, Rev. Canon. Chorlton-cum-Hardy, Manchester.
1887. ‡Tonge, James. Woodbine House, West Houghton, Bolton.
1865. ‡Tonks, Edmund, B.C.L. Packwood Grange, Knowle, Warwickshire.
1865. *Tonks, William Henry. The Rookery, Sutton Coldfield.
1873. *Tookey, Charles, F.C.S. Royal School of Mines, Jermyn-street, London, S.W.
1887. ‡Topham, F. 15 Great George-street, London, S.W.
1861. *Topham, John, A.I.C.E. High Elms, 265 Mare-street, Hackney, London, E.
1872. *TOPLEY, WILLIAM, F.R.S., F.G.S., A.I.C.E. Geological Survey Office, Jermyn-street, London, S.W.
1886. §Topley, Mrs. W. Hurstbourne, Elgin-road, Croydon.
1875. §Torr, Charles Hawley. St. Alban's Tower, Mansfield-road, Sherwood, Nottingham.
1886. ‡Torr, Charles Walker. Cambridge-street Works, Birmingham.
1884. ‡Torrance, John F. Folly Lake, Nova Scotia, Canada.
1884. *Torrance, Rev. Robert, D.D. Guelph, Ontario, Canada.
Towgood, Edward. St. Neot's, Huntingdonshire.
1873. ‡Townend, W. H. Heaton Hall, Bradford, Yorkshire.
1875. ‡Townsend, Charles. Avenue House, Cotham Park, Bristol.
1883. ‡*Townsend, Francis Edward.* 19 *Aughton-road, Birkdale, Southport.*
1861. ‡Townsend, William. Attleborough Hall, near Nuneaton.
1877. ‡Tozer, Henry. Ashburton.
1876. *TRAIL, Professor J. W. H., M.A., M.D., F.L.S. University of Aberdeen, Old Aberdeen.
1883. ‡TRAILL, A., M.D., LL.D. Ballylough, Bushmills, Ireland.
1870. ‡TRAILL, WILLIAM A. Giant's Causeway Electric Tramway, Portrush, Ireland.
1875. ‡Trapnell, Caleb. Severnleigh, Stoke Bishop.
1868. ‡TRAQUAIR, RAMSAY H., M.D., F.R.S., F.G.S., Keeper of the Natural History Collections, Museum of Science and Art, Edinburgh.
1884. ‡Trechmann, Charles O., Ph.D., F.G.S. Hartlepool.
1868. ‡Trehane, John. Exe View Lawn, Exeter.
Trench, F. A. Newlands House, Clondalkin, Ireland.
1883. ‡Trendell, Edwin James, J.P. Abbey House, Abingdon, Berks.
1884. ‡Trenham, Norman W. 18 St. Alexis-street, Montreal, Canada.
1884. §Tribe, Paul C. M. 44 West Oneida-street, Oswego, New York, U.S.A.
1879. ‡Trickett, F. W. 12 Old Haymarket, Sheffield.
1877. ‡TRIMEN, HENRY, M.B., F.R.S., F.L.S. British Museum, London, S.W.
1871. ‡TRIMEN, ROLAND, F.R.S., F.L.S., F.Z.S. Colonial Secretary's Office, Cape Town, Cape of Good Hope.
1860. §TRISTRAM, Rev. HENRY BAKER, D.D., LL.D., F.R.S., F.L.S., Canon of Durham. The College, Durham.

Year of Election.

1884. *Trotter, Alexander Pelham. 53 Addison-mansions, Blythe-road, West Kensington, London, W.
1885. §TROTTER, COUTTS, F.G.S., F.R.G.S. 17 Charlotte-square, Edinburgh.
1887. *Trouton, Frederick T. Trinity College, Dublin.
1869. ‡Troyte, C. A. W. Huntsham Court, Bampton, Devon.
1885. *Tubby, A. H. Guy's Hospital, London, S.E.
1847. *Tuckett, Francis Fox. Frenchay, Bristol.
1888. ‡Tuckett, William Fothergill, M.D. 18 Daniel-street, Bath.
Tuke, James H. Bancroft, Hitchin.
1871. ‡Tuke, J. Batty, M.D. Cupar, Fifeshire.
1887. ‡Tuke, W. C. 29 Princess-street, Manchester.
1883. ‡TUPPER, The Hon. Sir CHARLES, Bart., G.C.M.G., C.B., High Commissioner for Canada. 9 Victoria-chambers, London, S.W.
1855. ‡Turnbull, John. 37 West George-street, Glasgow.
1871. ‡Turnbull, William, F.R.S.E. Menslaws, Jedburgh, N.B.
1882. ‡Turner, G. S. 9 Carlton-crescent, Southampton.
1883. ‡Turner, Mrs. G. S. 9 Carlton-crescent, Southampton.
1888. ‡Turner, J. S., J.P. Granville, Lansdowne, Bath.
1886. *TURNER, THOMAS, A.R.S.M., F.C.S., F.I.C. Mason Science College, Birmingham.
1863. *TURNER, Sir WILLIAM, M.B., LL.D., D.C.L., F.R.S. L. & E., Professor of Anatomy in the University of Edinburgh. 6 Eton-terrace, Edinburgh.
1883. ‡Turrell, Miss S. S. High School, Redland-grove, Bristol.
1884. *Tutin, Thomas. Weston-on-Trent, Derby.
1884. *Tweddell, Ralph Hart. Provender, Faversham, Kent.
1886. *Twigg, G. H. Church-road, Moseley, Birmingham.
1847. ‡TWISS, Sir TRAVERS, Q.C., D.C.L., F.R.S., F.R.G.S. 3 Paper-buildings, Temple, London, E.C.
1888. §Tyack, Llewellyn Newton. University College, Bristol.
1882. §Tyer, Edward. Horneck, Fitzjohn's-avenue, Hampstead, London, N.W.
1865. §TYLOR, EDWARD BURNETT, D.C.L., LL.D., F.R.S., Keeper of the University Museum, Oxford.
1858. *TYNDALL, JOHN, D.C.L., LL.D., Ph.D., F.R.S., F.G.S., Hon. Professor of Natural Philosophy in the Royal Institution, London. Hind Head House, Haslemere, Surrey.
1883. ‡Tyrer, Thomas, F.C.S. Garden-wharf, Battersea, London, S.W.
1861. *Tysoe, John. 28 Heald-road, Bowdon, near Manchester.

1884. *Underhill, G. E., M.A. Magdalen College, Oxford.
1888. §Underhill, H. M. 7 High-street, Oxford.
1886. ‡Underhill, Thomas, M.D. West Bromwich.
1885. §Unwin, Howard. Newton-grove, Bedford Park, Chiswick, London.
1883. §Unwin, John. Park-crescent, Southport.
1883. §Unwin, William Andrews. The Briars, Freshfield, near Liverpool.
1876. *UNWIN, W. C., F.R.S., M.Inst.C.E., Professor of Engineering at the Central Institute, City and Guilds of London. 7 Palace-gate Mansions, Kensington, London, W.
1887. ‡Upton, Francis R. Orange, New Jersey, U.S.A.
1872. ‡Upward, Alfred. 11 Great Queen-street, Westminster, London, S.W.
1876. ‡Ure, John F. 6 Claremont-terrace, Glasgow.
1859. ‡Urquhart, W. Pollard. Craigston Castle, N.B.; and Castlepollard, Ireland.
1866. ‡Urquhart, William W. Rosebay, Broughty Ferry, by Dundee.
1880. ‡USSHER, W. A. E., F.G.S. 28 Jermyn-street, London, S.W.

Year of Election.

1885. ‡Vachell, Charles Tanfield, M.D. Cardiff.
1887. *Valentine, Miss Anne. The Elms, Hale, near Altrincham.
1888. ‡Vallentin, Rupert. 18 Kimberley-road, Falmouth.
1884. ‡Van Horne, W. C. Dorchester-street West, Montreal, Canada.
1883. *VanSittart, The Hon. Mrs. A. A. 11 Lypiatt-terrace, Cheltenham.
1886. ‡Vardy, Rev. A. R., M.A. King Edward's School, Birmingham.
1868. ‡Varley, Frederick H., F.R.A.S. Mildmay Park Works, Mildmay-avenue, Stoke Newington, London, N.
1865. *Varley, S. Alfred. 2 Hamilton-road, Highbury Park, London, N.
1870. ‡Varley, Mrs. S. A. 2 Hamilton-road, Highbury Park, London, N.
1869. ‡Varwell, P. Alphington-street, Exeter.
1884. ‡Vasey, Charles. 112 Cambridge-gardens, London, W.
1875. ‡Vaughan, Miss. Burlton Hall, Shrewsbury.
1883. ‡Vaughan, William. 42 Sussex-road, Southport.
1881. §Veley, V. H., M.A., F.C.S. University College, Oxford.
1873. *Verney, Captain Edmund H., R.N., F.R.G.S. Rhianva, Bangor, North Wales.
1883. *Verney, Mrs. Rhianva, Bangor, North Wales.
Verney, Sir Harry, Bart., M.P. Lower Claydon, Buckinghamshire.
Vernon, George John, Lord. Sudbury Hall, Derbyshire.
1883. ‡Vernon, H. H., M.D. York-road, Birkdale, Southport.
1864. *Vicary, William, F.G.S. The Priory, Colleton-crescent, Exeter.
1868. ‡Vincent, Rev. William. Postwick Rectory, near Norwich.
1883. *Vines, Sydney Howard, M.A., D.Sc., F.R.S., F.L.S., Professor of Botany in the University of Oxford. Fairacres, Oxford.
1856. ‡Vivian, Edward, M.A. Woodfield, Torquay
*Vivian, Sir H. Hussey, Bart., M.P., F.G.S. Park Wern, Swansea; and 27 Belgrave-square, London, S.W.

1886. *Wackrill, Samuel Thomas, J.P. Leamington.
1860. ‡Waddingham, John. Guiting Grange, Winchcombe, Gloucestershire.
1888. ‡Wadworth, H. A. Devizes, Wiltshire.
1884. ‡Wait, Charles E., Professor of Chemistry in the University of Tennessee. Knoxville, Tennessee, U.S.A.
1886. ‡Waite, J. W. The Cedars, Bestcot, Walsall.
1879. *Wake, Bernard. Abbeyfield, Sheffield.
1870. ‡Wake, Charles Staniland. Welton, near Brough, East Yorkshire.
1884. ‡Waldstein, Charles, M.A., Ph.D. Cambridge.
1873. ‡Wales, James. 4 Mount Royd, Manningham, Bradford, Yorkshire.
1882. *Walkden, Samuel. The Thorne, Bexhill, near Hastings, Sussex.
1885. ‡Walker, Baillie. 52 Victoria-street, Aberdeen.
1885. §Walker, Charles Clement, F.R.A.S. Lillieshall Old Hall, Newport, Shropshire.
1883. §Walker, Mrs. Emma. 14 Bootham-terrace, York.
1883. ‡Walker, E. R. Pagefield Ironworks, Wigan.
Walker, Frederick John. The Priory, Bathwick, Bath.
1883. ‡Walker, George. 11 Hamilton-square, Birkenhead, Liverpool.
1866. ‡Walker, H. Westwood, Newport, by Dundee.
1885. ‡Walker, General J. T., C.B., R.E., LL.D., F.R.S., F.R.G.S. 13 Cromwell-road, London, S.W.
1866. *Walker, John Francis, M.A., F.C.S., F.G.S., F.L.S. 45 Bootham, York.
1855. ‡Walker, John James, M.A., F.R.S. 12 Denning-road, Hampstead, London, N.W.
1881. ‡Walker, John Sydenham. 83 Bootham, York.
1867. *Walker, Peter G. 2 Airlie-place, Dundee.
1886. *Walker, Major Philip Billingsley. Sydney, New South Wales.

Year of Election.

1866. ‡Walker, S. D. 38 Hampden-street, Nottingham.
1884. ‡Walker, Samuel. Woodbury, Sydenham Hill, London, S.E.
1888. §Walker, Sydney F. 195 Severn-road, Cardiff.
1887. ‡Walker, T. A. 15 Great George-street, London, S.W.
1883. ‡Walker, Thomas A. 66 Leyland-road, Southport.
Walker, William. 47 Northumberland-street, Edinburgh.
1881. *Walker, William. 14 Bootham-terrace, York.
1883. ‡Wall, Henry. 14 Park-road, Southport.
1863. ‡WALLACE, ALFRED RUSSEL, D.C.L., F.L.S., F.R.G.S. Corfe View, Parkstone, Dorset.
1883. *Wallace, George J. Hawthornbank, Dunfermline.
1887. *Waller, Augustus, M.D. Weston Lodge, 16 Grove End-road, London, N.W.
1862. ‡Wallich, George Charles, M.D., F.L.S., F.R.G.S. 26 Addison-road North, Notting Hill, London, W.
1886. ‡Walliker, Samuel. Grandale, Westfield-road, Edgbaston, Birmingham.
1889. §Wallis, Arnold J., M.A. 4 Belvoir-terrace, Cambridge.
1883. ‡Wallis, Rev. Frederick. Caius College, Cambridge.
1884. §Wallis, Herbert. Redpath-street, Montreal, Canada.
1886. ‡Wallis, Whitworth. Westfield, Westfield-road, Edgbaston, Birmingham.
1883. ‡Walmesley, Oswald. Shevington Hall, near Wigan.
1887. ‡Walmsley, J. Winton, Patricroft, Manchester.
1883. ‡Walmsley, T. M. Clevelands, Chorley-road, Heaton, Bolton.
1862. ‡WALPOLE, The Right Hon. SPENCER HORATIO, M.A., D.C.L., F.R.S. Ealing, Middlesex, W.
1863. ‡Walters, Robert. Eldon-square, Newcastle-upon-Tyne.
1881. ‡Walton, Thomas, M.A. Oliver's Mount School, Scarborough.
1863. ‡Wanklyn, James Alfred. 7 Westminster-chambers, London, S.W.
1884. ‡Wanless, John, M.D. 88 Union-avenue, Montreal, Canada.
1872. ‡Warburton, Benjamin. Leicester.
1887. ‡Ward, A. W., M.A., Litt.D., Principal of Owens College, Manchester.
1874. §Ward, F. D., J.P., M.R.I.A. Clonaver, Strandtown, Co. Down.
1881. §Ward, George, F.C.S. Buckingham-terrace, Headingley, Leeds.
1879. ‡Ward, H. Marshall, M.A., F.R.S., F.L.S., Professor of Botany in the Royal Indian Civil Engineering College, Cooper's Hill, Egham.
1874. §Ward, John, F.S.A., F.G.S., F.R.G.S. Lenoxvale, Belfast.
1887. §Ward, John, F.G.S. 23 Stafford-street, Longton, Staffordshire.
1857. ‡Ward, John S. Prospect Hill, Lisburn, Ireland.
1880. **Ward, J. Wesney.* 5 *Holtham-road, St. John's Wood, London, N.W.*
1884. *Ward, John William. Newstead, Halifax.
1883. ‡Ward, Thomas, F.C.S. Arnold House, Blackpool.
1887. §Ward, Thomas. Brookfield House, Northwich.
1882. ‡Ward, William. Cleveland Cottage, Hill-lane, Southampton.
1867. ‡Warden, Alexander J. 23 Panmure-street, Dundee.
1858. ‡Wardle, Thomas. Leek Brook, Leek, Staffordshire.
1884. §Wardwell, George J. Rutland, Vermont, U.S.A.
1865. ‡Waring, Edward John, M.D., F.L.S. 49 Clifton-gardens, Maida Vale, London, W.
1887. *Waring, Richard S. Pittsburg, Pennsylvania, U.S.A.
1878. §WARINGTON, ROBERT, F.R.S., F.C.S. Harpenden, St. Albans, Herts.
1882. ‡Warner, F. W., F.L.S. 20 Hyde-street, Winchester.
1884. *Warner, James D. 199 Baltic-street, Brooklyn, U.S.A.
1875. ‡Warren, Algernon. 6 Windsor-terrace, Clifton, Bristol.
1887. §WARREN, Major-General Sir CHARLES, R.E., K.C.B., G.C.M.G., F.R.S., F.R.G.S. 44 St. George's-road, London, S.W.
1856. ‡Washbourne, Buchanan, M.D. Gloucester.

Year of Election.

1875. *Waterhouse, Lieut.-Colonel J. 40 Hamilton-terrace, London, N.W.
1870. ‡Waters, A. T. H., M.D. 29 Hope-street, Liverpool.
1875. ‡Watherston, Rev. Alexander Law, M.A., F.R.A.S. The Grammar School, Hinckley, Leicestershire.
1881. §Watherston, E. J. 12 Pall Mall East, London, S.W.
1887. ‡Watkin, F. W. 46 Auriol-road, West Kensington, London, W.
1884. ‡Watson, A. G., D.C.L. The School, Harrow, Middlesex.
1886. *Watson, C. J. 34 Smallbrook-street, Birmingham.
1883. ‡Watson, C. Knight, M.A. Society of Antiquaries, Burlington House, London, W.
1885. §Watson, Deputy Surgeon-General G. A. 4 St. Margaret's-terrace, Cheltenham.
1882. ‡WATSON, Rev. H. W., D.Sc., F.R.S. Berkeswell Rectory, Coventry.
1887. ‡Watson, J. Beauchamp. Gilt Hall, Carlisle.
1884. ‡Watson, John. Queen's University, Kingston, Ontario, Canada.
1889. §Watson, John, F.I.C. 19 Bloomfield-terrace, Gateshead.
1859. ‡WATSON, JOHN FORBES, M.A., M.D., F.L.S. India Museum, Exhibition-road, London, S.W.
1863. ‡Watson, Joseph. Bensham-grove, Gateshead.
1863. ‡Watson, R. Spence, LL.D., F.R.G.S. Bensham-grove, Gateshead.
1867. ‡Watson, Thomas Donald. 23 Cross-street, Finsbury, London, E.C.
1879. *WATSON, WILLIAM HENRY, F.C.S., F.G.S. Analytical Laboratory, The Folds, Bolton.
1882. ‡Watt, Alexander. 89 Hartington-road, Sefton Park, Liverpool.
1884. ‡Watt, D. A. P. 284 Upper Stanley-street, Montreal, Canada.
1869. ‡Watt, Robert B. E., F.R.G.S. Ashley-avenue, Belfast.
1888. ‡WATTS, B. H. 10 Rivers-street, Bath.
1875. *WATTS, JOHN, B.A., D.Sc. Merton College, Oxford.
1884. *Watts, Rev. Robert R. Stourpaine Vicarage, Blandford.
1870. §Watts, William, F.G.S. Oldham Corporation Waterworks, Piethorn, near Rochdale.
1873. *WATTS, W. MARSHALL, D.Sc. Giggleswick Grammar School, near Settle.
1883. §Watts, W. W., M.A., F.G.S. Broseley, Shropshire.
Waud, Rev. S. W., M.A., F.R.A.S., F.C.P.S. Rettenden, near Wickford, Essex.
1859. ‡Waugh, Edwin. New Brighton, near Liverpool.
1869. ‡Way, Samuel James. Adelaide, South Australia.
1883. ‡Webb, George. 5 Tenterden-street, Bury, Lancashire.
1871. ‡Webb, Richard M. 72 Grand-parade, Brighton.
1866. *WEBB, WILLIAM FREDERICK, F.G.S., F.R.G.S. Newstead Abbey, near Nottingham.
1886. §Webber, Major-General C. E., C.B. 17 Egerton-gardens, London, S.W.
1859. ‡Webster, John. Edgehill, Aberdeen.
1834. ‡Webster, Richard, F.R.A.S. 6 Queen Victoria-street, London, E.C.
1882. *Webster, Sir Richard Everard, Q.C., M.P. Hornton Lodge, Hornton-street, Kensington, London, S.W.
1889. *Webster, William, F.C.S. 50 Lee Park, Lee, Kent.
1884. *Wedekind, Dr. Ludwig, Professor of Mathematics at Karlsruhe. Karlsruhe.
1889. §Weeks, John G. Bedlington.
1886. ‡Weiss, Henry. Westbourne-road, Birmingham.
1865. ‡Welch, Christopher, M.A. United University Club, Pall Mall East, London, S.W.
1876. *WELDON, W. F. R., M.A. 1 Hoe-villas, Elliot-street, Plymouth.

Year of Election.

1880. *Weldon, Mrs. 1 Hoe-villas, Elliot-street, Plymouth.
1881. ‡Wellcome, Henry S. First Avenue Hotel, Holborn, London, W.C.
1879. §WELLS, CHARLES A., A.I.E.E. Lewes; and 45 Springfield-road, Brighton.
1881. ‡Wells, Rev. Edward, B.A. West Dean Rectory, Salisbury.
1883. ‡Welsh, Miss. Girton College, Cambridge.
1887. *Welton, T. A. Rectory House-grove, Clapham, London, S.W.
1850. ‡Wemyss, Alexander Watson, M.D. St. Andrews, N.B.
1881. *Wenlock, The Right Hon. Lord. 8 Great Cumberland-place, London, W.; and Escrick Park, Yorkshire.
Wentworth, Frederick W. T. Vernon. Wentworth Castle, near Barnsley, Yorkshire.
1864. *Were, Anthony Berwick. Hensingham, Whitehaven, Cumberland.
1886. §Wertheimer, J., B.A., B.Sc., F.C.S. 32 Lyddon-terrace, Leeds.
1865. ‡Wesley, William Henry. Royal Astronomical Society, Burlington House, London, W.
1853. ‡West, Alfred. Holderness-road, Hull.
1853. ‡West, Leonard. Summergangs Cottage, Hull.
1853. ‡West, Stephen. Hessle Grange, near Hull.
1882. §Westlake, Ernest, F.G.S. Fordingbridge, Hants.
1882. ‡Westlake, Richard. Portswood, Southampton.
1863. ‡Westmacott, Percy. Whickham, Gateshead, Durham.
1875. *Weston, Sir Joseph D. Dorset House, Clifton Down, Bristol.
1860. ‡WESTWOOD, JOHN O., M.A., F.L.S., Professor of Zoology in the University of Oxford. Oxford.
1882. §WETHERED, EDWARD, F.G.S. 5 Berkeley-place, Cheltenham.
1884. ‡Wharton, E. R., M.A. 4 Broad-street, Oxford.
1885. *Wharton, Captain W. J. L., R.N., F.R.S., F.R.G.S. Florys, Prince's-road, Wimbledon Park, Surrey.
1888. ‡Wheatcroft, William G. 6 Widcombe-terrace, Bath.
1853. ‡Wheatley, E. B. Cote Wall, Mirfield, Yorkshire.
1866. ‡Wheatstone, Charles C. 19 Park-crescent, Regent's Park, London, N.W.
1884. ‡Wheeler, Claude L. 123 Metcalfe-street, Montreal, Canada.
1847. ‡*Wheeler, Edmund, F.R.A.S. 48 Tollington-road, London, N.*
1883. *Wheeler, George Brash. Elm Lodge, Wickham-road, Beckenham, Kent.
1878. *Wheeler, W. H., M.Inst.C.E. Boston, Lincolnshire.
1888. §Whelen, John Leman. 73 Fellowes-road, London, N.W.
1883. ‡Whelpton, Miss K. Newnham College, Cambridge.
1888. *Whidborne, Miss Alice Maria. Charanté, Torquay.
1888. *Whidborne, Miss Constance Mary. Charanté, Torquay.
1879. *WHIDBORNE, Rev. GEORGE FERRIS, M.A., F.G.S. Charanté, Torquay.
1873. ‡Whipple, George Matthew, B.Sc., F.R.A.S. Kew Observatory, Richmond, Surrey.
1884. ‡Whischer, Arthur Henry. Dominion Lands Office, Winnipeg, Canada.
1887. ‡*Whitaker, E. J. Burnley, Lancashire.*
1874. ‡Whitaker, Henry, M.D. 33 High-street, Belfast.
1883. *Whitaker, T. Saville Heath, Halifax.
1859. *WHITAKER, WILLIAM, B.A., F.R.S., F.G.S. Geological Survey Office, Jermyn-street, London, S.W.; and 33 East Park-terrace, Southampton.
1886. ‡Whitcombe, E. B. Borough Asylum, Winson Green, Birmingham.
1886. ‡White, Alderman, J.P. Sir Harry's-road, Edgbaston, Birmingham.

Year of Election.

1876. ‡White, Angus. Easdale, Argyllshire.
1886. ‡White, A. Silva, Secretary to the Royal Scottish Geographical Society, Edinburgh.
1883. ‡White, Charles. 23 Alexandra-road, Southport.
1882. ‡White, Rev. George Cecil, M.A. Nutshalling Rectory, Southampton.
1885. *White, J. Martin. Spring Grove, Dundee.
1873. ‡White, John. Medina Docks, Cowes, Isle of Wight.
1859. ‡White, John Forbes. 311 Union-street, Aberdeen.
1883. ‡White, John Reed. Rossall School, near Fleetwood.
1865. ‡White, Joseph. Regent's-street, Nottingham.
1869. ‡*White, Laban. Blandford, Dorset.*
1884. ‡White, R. 'Gazette' Office, Montreal, Canada.
1859. ‡White, Thomas Henry. Tandragee, Ireland.
1877. *White, William. 9 The Paragon, Blackheath, London, S.E.
1883. *White, Mrs. 9 The Paragon, Blackheath, London, S.E.
1886. §White, William. 4 Mecklenburgh-square, London, W.C.
1861. *Whitehead, John B. Ashday Lea, Rawtenstall, Manchester.
1861. *Whitehead, Peter Ormerod. 4 Reformation-street, Fold's-road, Bolton.
1883. ‡Whitehead, P. J. 6 Cross-street, Southport.
1855. *Whitehouse, Wildeman W. O. 18 Salisbury-road, West Brighton.
1871. ‡Whitelaw, Alexander. 1 Oakley-terrace, Glasgow.
1884. ‡Whiteley, Joseph. Huddersfield.
1881. ‡Whitfield, John, F.C.S. 113 Westborough, Scarborough.
1866. ‡Whitfield, Samuel. Eversfield, Eastnor-grove, Leamington.
1852. ‡Whitla, Valentine. Beneden, Belfast.
Whitley, Rev. Canon C. T., M.A., F.R.A.S. Bedlington Vicarage, Northumberland.
1857. *Whitty, Rev. John Irwine, M.A., D.C.L., LL.D. 13 Ulysses-road, West Hampstead, London, N.W.
1887. ‡Whitwell, William. Overdene, Saltburn-by-the-Sea.
1874. *Whitwill, Mark. Redland House, Bristol.
1883. ‡Whitworth, James. 88 Portland-street, Southport.
1870. ‡Whitworth, Rev. W. Allen, M.A. Glenthorne-road, Hammersmith, London, W.
1888. ‡Wickham, Rev. F. D. C. Horsington Rectory, Bath.
1865. ‡Wiggin, Henry, M.P. Metchley Grange, Harborne, Birmingham.
1886. ‡Wiggin, Henry A. The Lea, Harborne, Birmingham.
1885. ‡Wigglesworth, Alfred. Gordondale House, Aberdeen.
1883. ‡Wigglesworth, Mrs. New Parks House, Falsgrave, Scarborough.
1881. *Wigglesworth, Robert. Beckwith Knowle, near Harrogate.
1878. ‡Wigham, John R. Albany House, Monkstown, Dublin.
1883. ‡Wigner, G. W. Plough-court, 37 Lombard-street, London, E.C.
1884. ‡*Wilber, Charles Dana, LL.D. Grand Pacific Hotel, Chicago, U.S.A.*
1889. *Wilberforce, L. R., M.A. Trinity College, Cambridge.
1881. ‡Wilberforce, W. W. Fishergate, York.
1887. ‡Wild, George. Bardsley Colliery, Ashton-under-Lyne.
1887. *Wilde, Henry, F.R.S. The Hurst, Alderley Edge, Manchester.
1887. ‡Wilkinson, C. H. Slaithwaite, near Huddersfield.
1857. ‡Wilkinson, George. Temple Hill, Killiney, Co. Dublin.
1886. *Wilkinson, J. H. Corporation-street, Birmingham.
1879. ‡Wilkinson, Joseph. York.
1887. *Wilkinson, Thomas Read. The Polygon, Ardwick, Manchester.
1872. ‡Wilkinson, William. 168 North-street, Brighton.
1869. §Wilks, George Augustus Frederick, M.D. Stanbury, Torquay.
1859. ‡Willet, John, M.Inst.C.E. 35 Albyn-place, Aberdeen.
1872. ‡Willett, Henry, F.G.S. Arnold House, Brighton.

Year of Election.

1861. *Williams, Charles Theodore, M.A., M.B. 47 Upper Brook-street, Grosvenor-square, London, W.
1887. §Williams, E. Leader, M.Inst.C E. The Oaks, Altrincham.
1883. *Williams, Edward Starbuck. Ty-ar-y-graig, Swansea.
1861. *Williams, Harry Samuel, M.A., F.R.A.S. 1 Gorse-lane, Swansea.
1875. **Williams, Rev. Herbert A., M.A. S.P.G. College, Trichinopoly, India.*
1883. ‡Williams, Rev. H. A. The Ridgeway, Wimbledon, Surrey.
1857. ‡Williams, Rev. James. Llanfairinghornwy, Holyhead.
1888. ‡Williams, James. Bladud Villa, Entryhill, Bath.
1887. ‡Williams, J. Francis, Ph.D. Salem, New York, U.S.A.
1888. *Williams, Miss Katherine. Llandaff House, Pembroke-vale, Clifton, Bristol.
1875. *Williams, M. B. Killay House, near Swansea.
1879. ‡WILLIAMS, MATTHEW W., F.C.S. Queenwood College, Stockbridge, Hants.
1886. §Williams, Richard, J.P. Brunswick House, Wednesbury.
Williams, Robert, M.A. Bridehead, Dorset.
1883. ‡Williams, R. Price. North Brow, Primrose Hill, London, N.W.
1883. §Williams, T. H. 2 Chapel-walk, South Castle-street, Liverpool.
1883. §Williams, T. Howell. 58 Lady Margaret-road, London, N.W.
1888. ‡Williams, W. Cloud House, Stapleford, Nottinghamshire.
1877. *WILLIAMS, W. CARLETON, F.C.S. Firth College, Sheffield.
1865. ‡Williams, W. M. Stonebridge Park, Willesden.
1883. ‡Williamson, Miss. Sunnybank, Ripon, Yorkshire.
1850. *WILLIAMSON, ALEXANDER WILLIAM, Ph.D., LL.D., D.C.L., F.R.S., F.C.S., Corresponding Member of the French Academy. (GENERAL TREASURER.) 17 Buckingham-street, London, W.C.
1857. ‡WILLIAMSON, BENJAMIN, M.A., F.R.S., Professor of Natural Philosophy in the University of Dublin. Trinity College, Dublin.
1876. ‡Williamson, Rev. F. J. Ballantrae, Girvan, N.B.
1863. ‡Williamson, John. South Shields.
WILLIAMSON, WILLIAM C., LL.D., F.R.S., Professor of Botany in Owens College, Manchester. 4 Egerton-road, Fallowfield, Manchester.
1889. §Willis, James. 14 Portland-terrace, Newcastle-upon-Tyne.
1883. ‡*Willis, T. W. 51 Stanley-street, Southport.*
1882. ‡Willmore, Charles. Queenwood College, near Stockbridge, Hants.
1859. *Wills, The Hon. Sir Alfred. Clive House, Esher, Surrey.
1886. ‡Wills, A. W. Wylde Green, Erdington, Birmingham.
1886. ‡Wilson, Alexander B. Holywood, Belfast.
1885. ‡Wilson, Alexander H. 2 Albyn-place, Aberdeen.
1878. ‡Wilson, Professor Alexander S., M.A., B.Sc. 124 Bothwell-street, Glasgow.
1859. ‡Wilson, Alexander Stephen. North Kinmundy, Summerhill, by Aberdeen.
1876. ‡Wilson, Dr. Andrew. 118 Gilmore-place, Edinburgh.
1874. ‡WILSON, Colonel Sir C. W., R.E., K.C.B., K.C.M.G., D.C.L., F.R.S., F R.G.S. Ordnance Survey Office, Southampton.
1850. ‡Wilson, Sir Daniel. Toronto, Canada.
1876. ‡Wilson, David. 124 Bothwell-street, Glasgow.
1863. ‡Wilson, Frederic R. Alnwick, Northumberland.
1847. *Wilson, Frederick. 73 Newman-street, Oxford-street, London, W.
1885. ‡*Wilson, Brigade-Surgeon G. A. East India United Service Club, St. James's-square, London, S.W.*
1875. ‡Wilson, George Fergusson, F.R.S., F.C.S., F.L.S. Heatherbank, Weybridge Heath, Surrey.

Year of Election.

1874. *Wilson, George Orr. Dunardagh, Blackrock, Co. Dublin.
1863. ‡Wilson, George W. Heron Hill, Hawick, N.B.
1883. *Wilson, Henry, M.A. Eastnor, Malvern Link, Worcestershire.
1879. ‡Wilson, Henry J. 255 Pitsmoor-road, Sheffield.
1885. ‡Wilson, J. Dove, LL.D. 17 Rubislaw-terrace, Aberdeen.
1886. ‡Wilson, J. E. B. Woodslee, Wimbledon, Surrey.
1865. ‡WILSON, Rev. JAMES M., M.A., F.G.S. The College, Clifton, Bristol.
1884. ‡Wilson, James S. Grant. Geological Survey Office, Sheriff Court-buildings, Edinburgh.
1858. *Wilson, John. Seacroft Hall, near Leeds.
1879. ‡Wilson, John Wycliffe. Eastbourne, East Bank-road, Sheffield.
1876. ‡Wilson, R. W. R. St. Stephen's Club, Westminster, S.W.
1847. *Wilson, Rev. Sumner. Preston Candover Vicarage, Basingstoke.
1883. ‡Wilson, T. Rivers Lodge, Harpenden, Hertfordshire.
1861. ‡Wilson, Thos. Bright. 4 Hope View, Fallowfield, Manchester.
1887. §Wilson, W., jun. Hillock, Terpersie, by Alford, Aberdeenshire.
1871. *Wilson, William E. Daramona House, Rathowen, Ireland.
1861. *WILTSHIRE, Rev. THOMAS, M.A., F.G.S., F.L.S., F.R.A.S., Assistant Professor of Geology and Mineralogy in King's College, London. 25 Granville-park, Lewisham, London, S.E.
1877. ‡Windeatt, T. W. Dart View, Totnes.
1886. §Windle, Bertram C. A., M.A., M.D., Professor of Anatomy in Queen's College, Birmingham.
1887. ‡Windsor, William Tessimond. Sandiway, Ashton-on-Mersey.
1886. ‡*Winter, George W. 55 Wheeley's-road, Edgbaston, Birmingham.*
1863. *WINWOOD, Rev. H. H., M.A., F.G.S. 11 Cavendish-crescent, Bath.
1888. ‡WODEHOUSE, E. R., M.P. 56 Chester-square, London, S.W.
1883. §Wolfenden, Samuel. Cowley Hill, St. Helens, Lancashire.
1884. ‡Womack, Frederick, Lecturer on Physics and Applied Mathematics at St. Bartholomew's Hospital. 68 Abbey-road, London, N.W.
1881. *Wood, Alfred John. 5 Cambridge-gardens, Richmond, Surrey.
1883. §Wood, Mrs. A. J. 5 Cambridge-gardens, Richmond, Surrey.
1863. *Wood, Collingwood L. Freeland, Forgandenny, N.B.
1861. *Wood, Edward T. Blackhurst, Brinscall, Chorley, Lancashire.
1883. ‡Wood, Miss Emily F. Egerton Lodge, near Bolton, Lancashire.
1875. *Wood, George William Rayner. Singleton, Manchester.
1878. §WOOD, H. TRUEMAN, M.A. Society of Arts, John-street, Adelphi, London, W.C.
1883. *WOOD, JAMES, LL.D. Grove House, Scarisbrick-street, Southport.
1881. §Wood, John, B.A., F.R.A.S. Wharfedale College, Boston Spa, Yorkshire.
1883. *Wood, J. H. Woodbine Lodge, Scarisbrick New-road, Southport.
1886. ‡Wood, Rev. Joseph. Carpenter-road, Birmingham.
1883. ‡Wood, Mrs. Mary. Ellison-place, Newcastle-on-Tyne.
1864. ‡Wood, Richard, M.D. Driffield, Yorkshire.
1871. ‡Wood, Provost T. Barleyfield, Portobello, Edinburgh.
1850. ‡Wood, Rev. Walter. Elie, Fife.
1865. *Wood, William, M.D. 99 Harley-street, London, W.
1872. §Wood, William Robert. Carlisle House, Brighton.
*Wood, Rev. William Spicer, M.A., D.D. Higham, Rochester.
1863. *WOODALL, JOHN WOODALL, M.A., F.G.S. St. Nicholas House, Scarborough.
1884. ‡Woodbury, C. J. H. 31 Devonshire-street, Boston, U.S.A.
1883. ‡Woodcock, Herbert S. The Elms, Wigan.
1884. ‡Woodcock, T., M.A. 150 Cromwell-road, London, S.W.
1884. ‡Woodd, Arthur B. Woodlands, Hampstead, London, N.W.

Year of Election.

1850. *Woodd, Charles H. L., F.G.S. Roslyn House, Hampstead, London, N.W.
1871. ‡*Woodiwis, James. 51 Back George-street, Manchester.*
1888. *Woodiwiss, Alfred. Belair, Trafalgar-road, Birkdale, Southport.
1888. *Woodiwiss, Mrs. Alfred. Belair, Trafalgar-road, Birkdale, Southport.
1872. ‡Woodman, James. 26 Albany-villas, Hove, Sussex.
*Woods, Edward, M.Inst.C.E. 68 Victoria-street, Westminster, London, S.W.
1883. ‡Woods, Dr. G. A., F.R.S.E., F.R.M.S. Carlton House, 57 Hoghton-street, Southport.
Woods, Samuel. 1 Drapers'-gardens, Throgmorton-street, London, E.C.
1888. ‡Woodthorpe, Colonel. Messrs. King & Co., 45 Pall Mall, London, S.W.
1887. *Woodward, Arthur Smith, F.G.S., F.L.S. 183B King's-road, Chelsea, London, S.W.
*Woodward, C. J., B.Sc. 97 Harborne-road, Birmingham.
1886. ‡Woodward, Harry Page, F.G.S. 129 Beaufort-street, London, S.W.
1866. ‡Woodward, Henry, LL.D., F.R.S., F.G.S., Keeper of the Department of Geology, British Museum (Natural History), Cromwell-road, London, S.W.
1870. ‡Woodward, Horace B., F.G.S. Geological Museum, Jermyn-street, London, S.W.
1881. ‡Wooler, W. A. Sadberge Hall, Darlington.
1884. *Woolcock, Henry. Rickerby House, St. Bees.
1877. ‡Woollcombe, Surgeon-Major Robert W. 14 Acre-place, Stoke, Devonport.
1883. *Woolley, George Stephen. 69 Market-street, Manchester.
1856. ‡Woolley, Thomas Smith, jun. South Collingham, Newark.
Worcester, The Right Rev. Henry Philpott, D.D., Lord Bishop of. Hartlebury Castle, Kidderminster.
1874. ‡Workman, Charles. Ceara, Windsor, Belfast.
1878. ‡Wormell, Richard, M.A., D.Sc. Roydon, near Ware, Hertfordshire.
1863. *Worsley, Philip J. Rodney Lodge, Clifton, Bristol.
1855. *Worthington, Rev. Alfred William, B.A. Stourbridge, Worcestershire.
Worthington, Archibald. Whitchurch, Salop.
Worthington, James. Sale Hall, Ashton-on-Mersey.
1856. ‡Worthy, George S. 2 Arlington-terrace, Mornington-crescent, Hampstead-road, London, N.W.
1884. ‡Wragge, Edmund. 109 Wellesley-street, Toronto, Canada.
1879. ‡Wrentmore, Francis. 34 Holland Villas-road, Kensington, London, S.W.
1883. *Wright, Rev. Arthur, M.A. Queen's College, Cambridge.
1883. *Wright, Rev. Benjamin, M.A. The Rectory, Darlaston.
1871. §Wright, C. R. A., D.Sc., F.R.S., F.C.S., Lecturer on Chemistry in St. Mary's Hospital Medical School, Paddington, London, W.
1861. *Wright, E. Abbot. Castle Park, Frodsham, Cheshire.
1857. ‡Wright, E. Perceval, M.A., M.D., F.L.S., M.R.I.A., Professor of Botany and Director of the Museum, Dublin University. 5 Trinity College, Dublin.
1886. ‡Wright, Frederick William. 4 Full-street, Derby.
1884. ‡Wright, Harrison. Wilkes' Barré, Pennsylvania, U.S.A.
1876. ‡Wright, James. 114 John-street, Glasgow.
1874. ‡*Wright, Joseph. Cliftonville, Belfast.*
1865. ‡Wright, J. S. 168 Brearley-street West, Birmingham.

Year of Election.

1884. ‡Wright, Professor R. Ramsay, M.A., B.Sc. University College, Toronto, Canada.
WRIGHT, T. G., M.D. Milnes House, Wakefield.
1876. ‡Wright, William. 31 Queen Mary-avenue, Glasgow.
1871. ‡WRIGHTSON, THOMAS, M.Inst.C.E., F.G.S. Norton Hall, Stockton-on-Tees.
1887. ‡Wrigley, Rev. Dr., M.A., M.D., F.R.A.S. 15 Gauden-road, London, S.W.
1876. ‡WUNSCH, EDWARD ALFRED, F.G.S. Carharrack, Scorrier, Cornwall.
1867. ‡Wylie, Andrew. Prinlaws, Fifeshire.
1883. ‡Wyllie, Andrew. 10 Park-road, Southport.
1885. ‡Wyness, James D., M.D. 53 School-hill, Aberdeen.
1871. ‡Wynn, Mrs. Williams. Cefn, St. Asaph.
1862. ‡WYNNE, ARTHUR BEEVOR, F.G.S. Geological Survey Office, 14 Hume-street, Dublin.

1875. ‡Yabbicom, Thomas Henry. 37 White Ladies-road, Clifton, Bristol.
*Yarborough, George Cook. Camp's Mount, Doncaster.
1865. ‡Yates, Edwin. Stonebury, Edgbaston, Birmingham.
1883. ‡Yates, James. Public Library, Leeds.
1867. ‡Yeaman, James. Dundee.
1887. ‡Yeats, Dr. Chepstow.
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